

New Results for Winter 2012

Rencontres de Moriond



Christian Schwanenberger
University of Manchester

Joint Experimental-Theoretical Seminar

Fermilab, March 9, 2012



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Bottom Physics

Analysis	Luminosity	More Information
Confirmation of a new narrow state decaying to Y(1S)+gamma	1.0 fb ⁻¹	Publication
Measurement of the relative branching ratio B0s->J/psi f0(980) to B0s->J/psi phi	8.0 fb ⁻¹	Publication

Electroweak Physics

Analysis	Luminosity	More Information
Measurement of the W boson mass with the D0 detector	4.3+1.0 fb ⁻¹	Publication
A measurement of the WZ and ZZ production cross sections using leptonic final states in 8.6 fb ⁻¹ of ppbar collisions	8.6 fb ⁻¹	Publication
Measurements of WW and WZ production in W + jets final states in ppbar collisions	4.3 fb ⁻¹	Publication
Zgamma production and limits on ZZgamma and Zgammagamma couplings in ppbar collisions at sqrt(s)=1.96 TeV	6.2 fb ⁻¹	Publication
W+gamma production and limits on anomalous WWgamma couplings in ppbar collisions at sqrt(s)=1.96 TeV	4.2 fb ⁻¹	Publication

New Phenomena

Analysis	Luminosity	More Information
Search for Z gamma events with large missing transverse energy in 6.2 fb ⁻¹ of ppbar collisions	6.2 fb ⁻¹	Publication
A Search for pair production of the scalar top quark in muon+tau final states	7.3 fb ⁻¹	Publication
Search for universal extra dimensions in ppbar collisions	7.3 fb ⁻¹	Publication
A search for charged massive long-lived particles	5.2 fb ⁻¹	Publication

Higgs Physics

Analysis	Luminosity	More Information
Combined CDF and D0 Search for Standard Model Higgs Boson Production with up to 10 fb ⁻¹ of Data	up to 10 fb ⁻¹	Preliminary
Combined Search for the Standard Model Higgs Boson from the D0 experiment in up to 9.7 fb ⁻¹ of Data	up to 9.7 fb ⁻¹	Preliminary
Combined CDF and D0 measurement of WZ and ZZ production in final states with b-tagged jets	9.7 fb ⁻¹	Preliminary
Search for the standard model Higgs boson in tau lepton pair final states	9.7 fb ⁻¹	Preliminary
Search for Associated Higgs Boson Production VII->e+ ->nu_e nu+ ->nu_mu Like Charged Electron Muon pairs using 9.7 fb ⁻¹ of ppbar Collisions at sqrt(s) = 1.96 TeV	9.7 fb ⁻¹	Preliminary
Search for Higgs boson production in dilepton plus missing transverse energy final states with 8.6-9.7 fb ⁻¹ of ppbar collisions at sqrt(s)=1.96 TeV	9.7 fb ⁻¹	Preliminary
Search for Higgs boson in final states with lepton, missing energy and at least two jets using b-jet identification in 9.7 fb ⁻¹ of Tevatron data	9.7 fb ⁻¹	Preliminary
Search for ZZ->llbb production in 9.7 fb ⁻¹ of ppbar collisions	9.7 fb ⁻¹	Preliminary
Search for the standard model Higgs boson in the ZZ->vvbb channel in Run II data	9.5 fb ⁻¹	Preliminary
Search for standard model Higgs boson in the tau lepton mu + X final state in 7.0 fb ⁻¹ of ppbar collisions at sqrt(s) = 1.96 TeV	7.0 fb ⁻¹	Preliminary
Search for standard model Higgs bosons with trilepton and missing transverse energy with 9.7 fb ⁻¹ of ppbar collisions at sqrt(s) = 1.96 TeV	9.7 fb ⁻¹	Preliminary
Search for a Fermiophobic Higgs Boson in the di-photon final state using 9.7 fb ⁻¹ of D0 data	9.7 fb ⁻¹	Preliminary
Search for the Standard Model Higgs Boson in gammagamma + X final states at D0 using 9.7 fb ⁻¹ data	9.7 fb ⁻¹	Preliminary
Evidence for WZ and ZZ production in final states with b-tagged jets	7.5-8.4 fb ⁻¹	Preliminary
Search for WH associated production with 8.5 fb ⁻¹ of Tevatron data (including WZ+ZZ cross section)	8.5 fb ⁻¹	Preliminary
Search for ZZ->llbb production in 8.6 fb ⁻¹ of ppbar collisions (including WZ+ZZ cross section)	8.6 fb ⁻¹	Preliminary
Search for WH associated production in ppbar collisions at sqrt(s)=1.96 TeV	5.3 fb ⁻¹	Publication
Search for Higgs bosons of the minimal supersymmetric standard model in ppbar collisions at sqrt(s)=1.96 TeV	5.2-7.3 fb ⁻¹	Publication

QCD Results

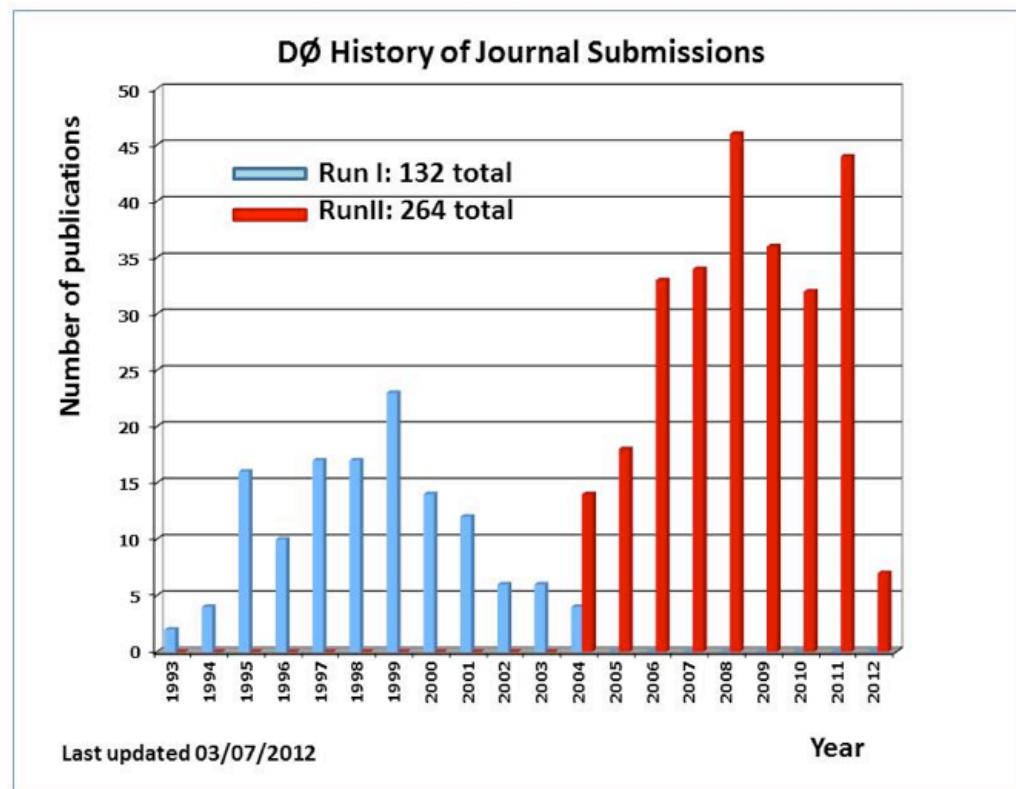
Analysis	Luminosity	More Information
Measurement of the photon+b-jet production cross section in ppbar collisions at sqrt(s) = 1.96 TeV	8.7 fb ⁻¹	Publication
Measurements of the inclusive jet cross section in ppbar collisions at sqrt(s)=1.96 TeV	0.7 fb ⁻¹	Publication

Top Physics

Analysis	Luminosity	More Information
Search for violation of Lorentz invariance in tbar production and decay at the D0 experiment	5.3 fb ⁻¹	Publication
Combination of CDF and D0 measurements of the W boson helicity in top quark decays	5.4 fb ⁻¹	Publication
Measurement of the top quark mass in ppbar collisions using events with two leptons	4.3 fb ⁻¹	Publication
An improved determination of the width of the top quark	5.4 fb ⁻¹	Publication
Search for a narrow tbar resonance in ppbar collisions at sqrt(s)=1.96 TeV	5.4 fb ⁻¹	Publication
Search for anomalous Wtb couplings in single top quark production in ppbar collisions at sqrt(s)=1.96 TeV	5.4 fb ⁻¹	Publication
Evidence for spin correlation in tbar production	5.4 fb ⁻¹	Publication
Measurements of single top quark production cross sections and IVtbt in ppbar collisions at sqrt(s)=1.96 TeV	5.4 fb ⁻¹	Publication

since September 2011:

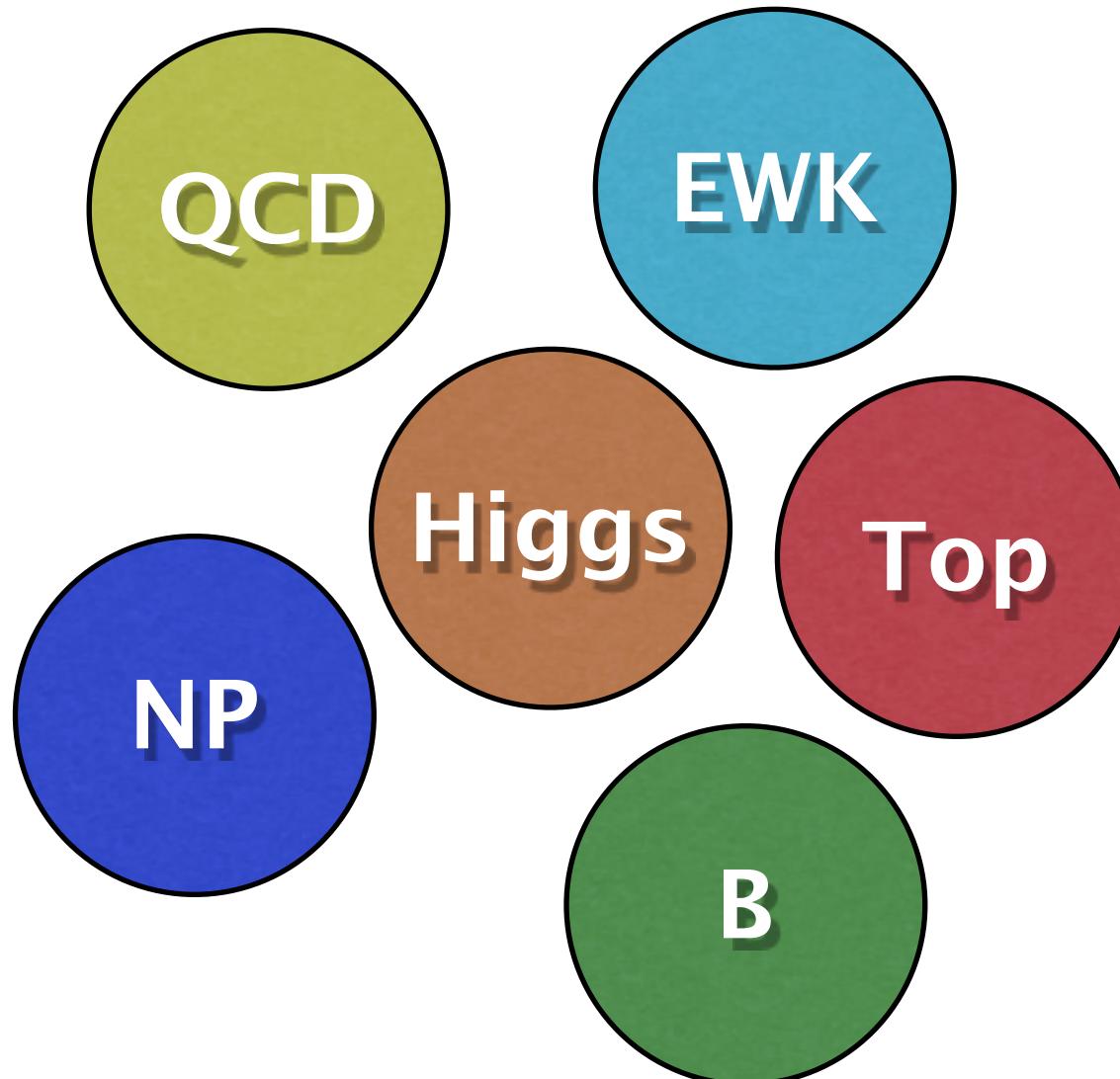
- 16 preliminary results
- 23 journal papers (~0.8/week)



<http://www-d0.fnal.gov/Run2Physics/D0Winter2012.html>



DØ Physics Results for Winter 2012

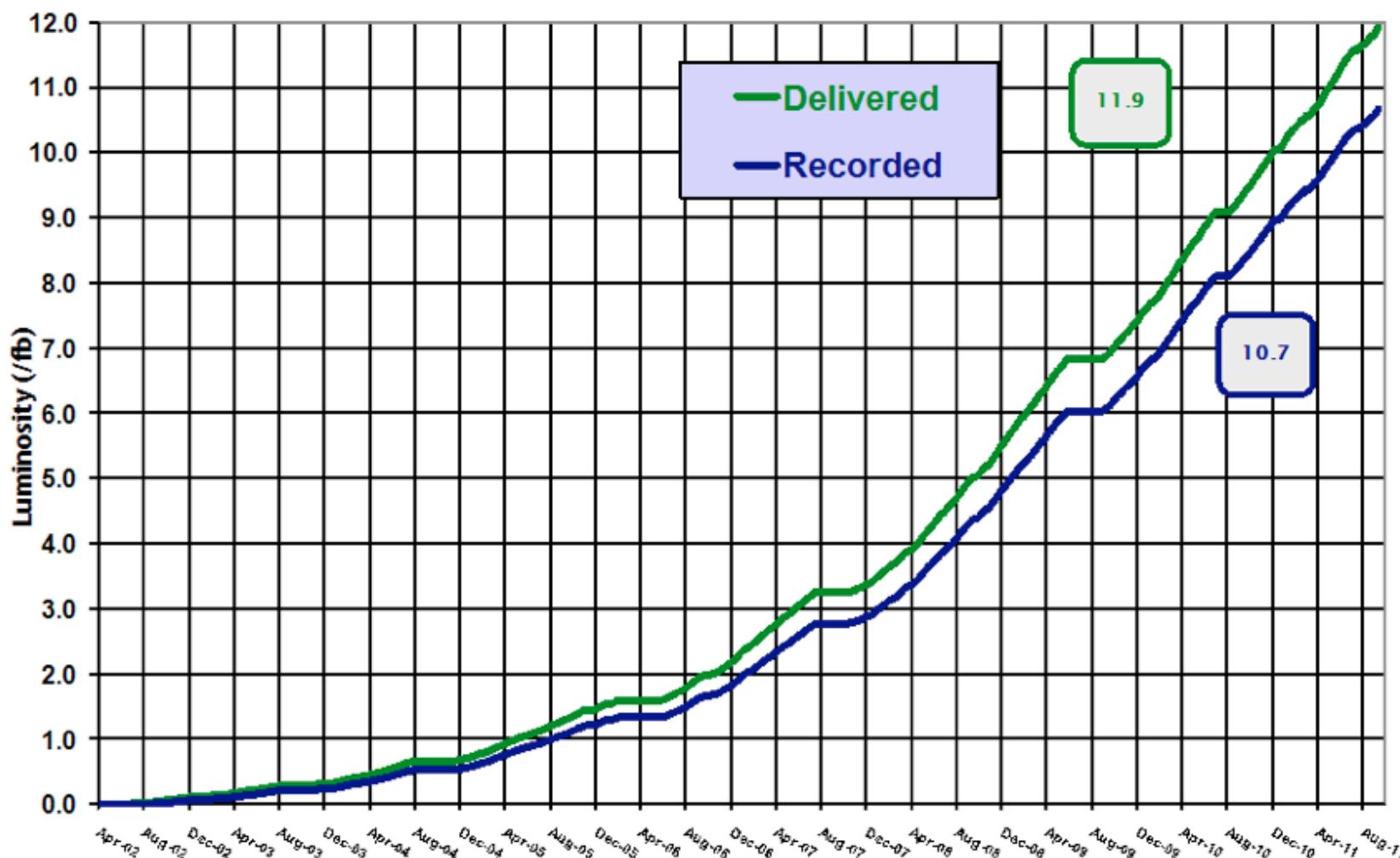


Many Thanks to Accelerator Division!



Run II Integrated Luminosity

19 April 2002 - 30 September 2011



full data set
analysed



Many thanks to my colleagues!

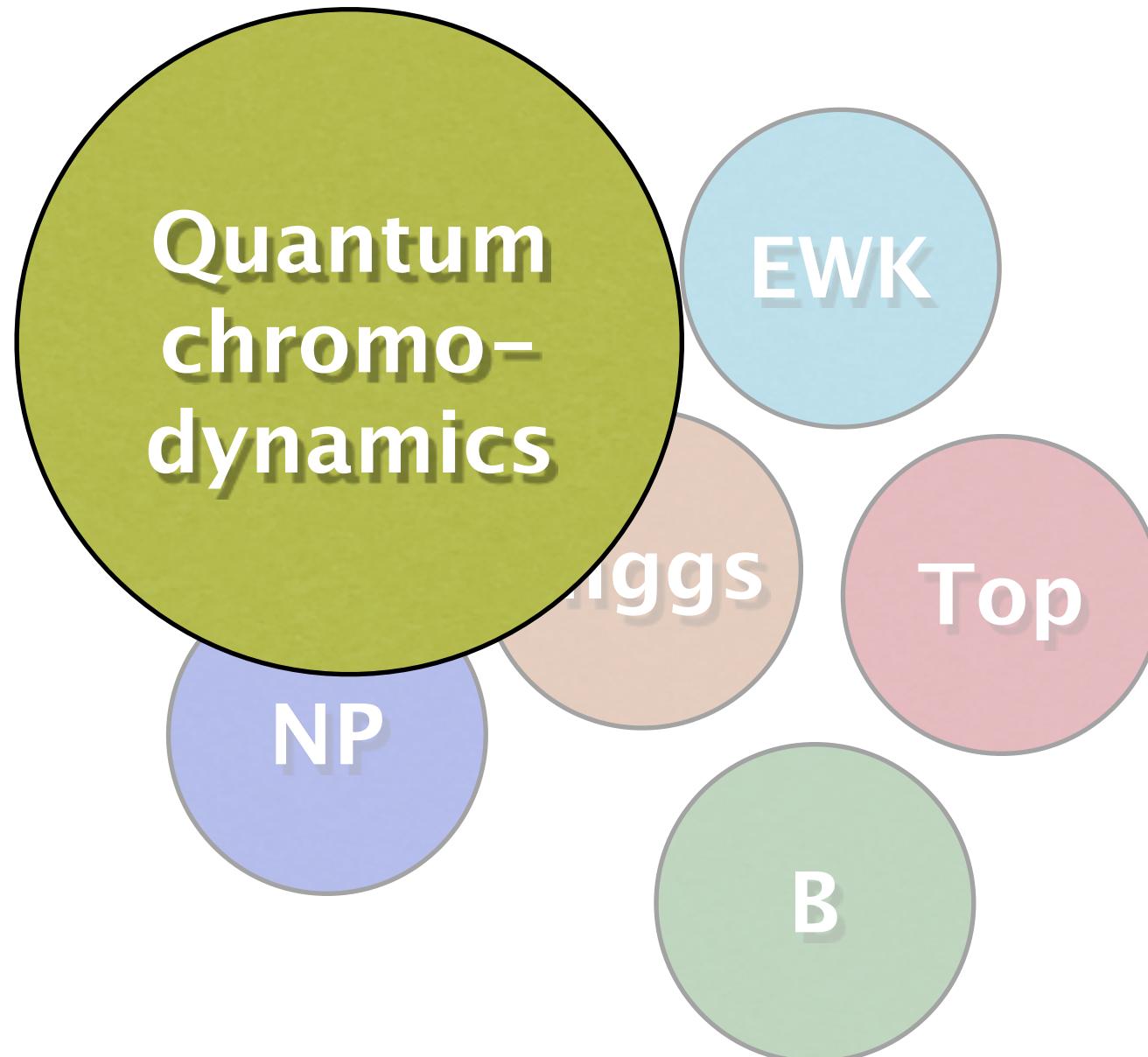
The D \emptyset Collaboration



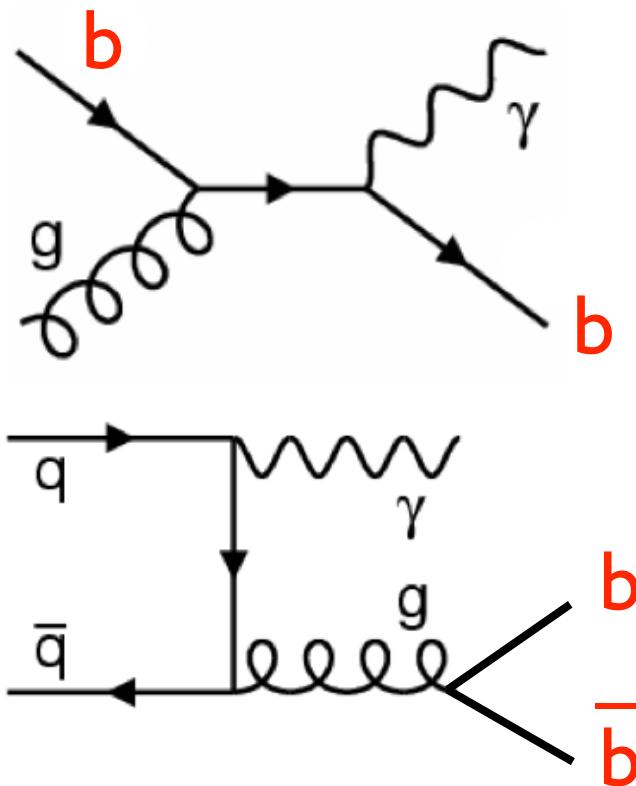
446 members in 82 institutions from 18 countries



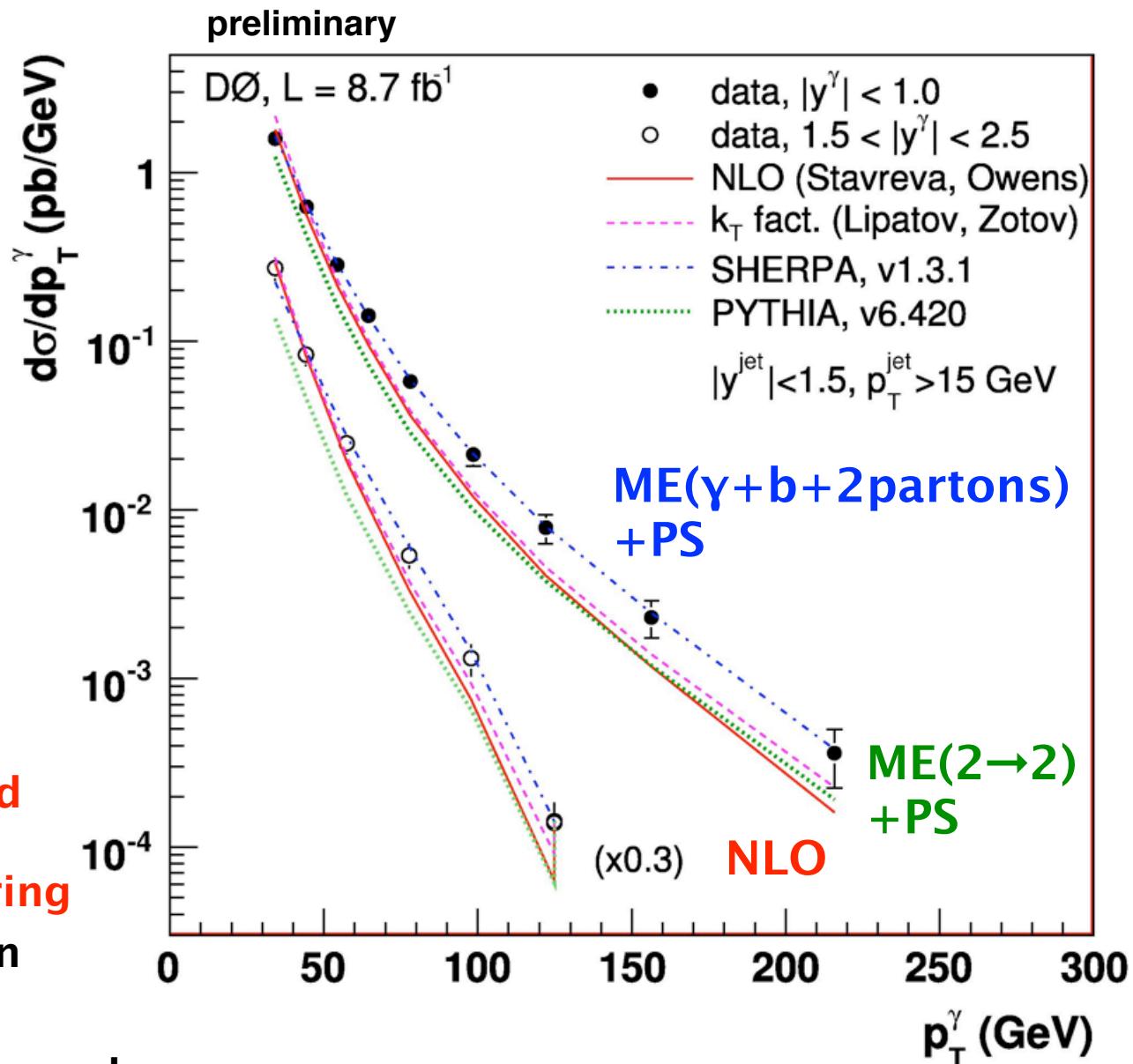
DØ Physics Results for Winter 2012



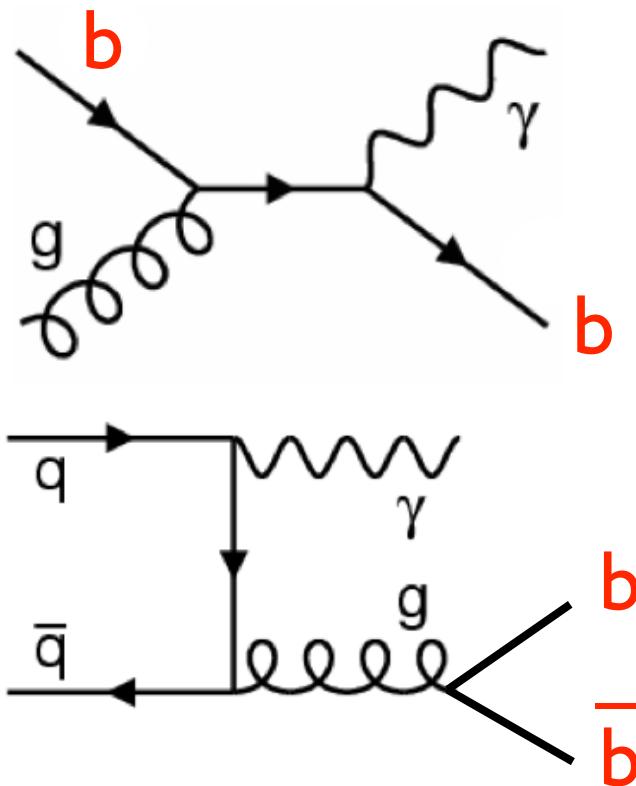
Photon+b-jet Cross Section



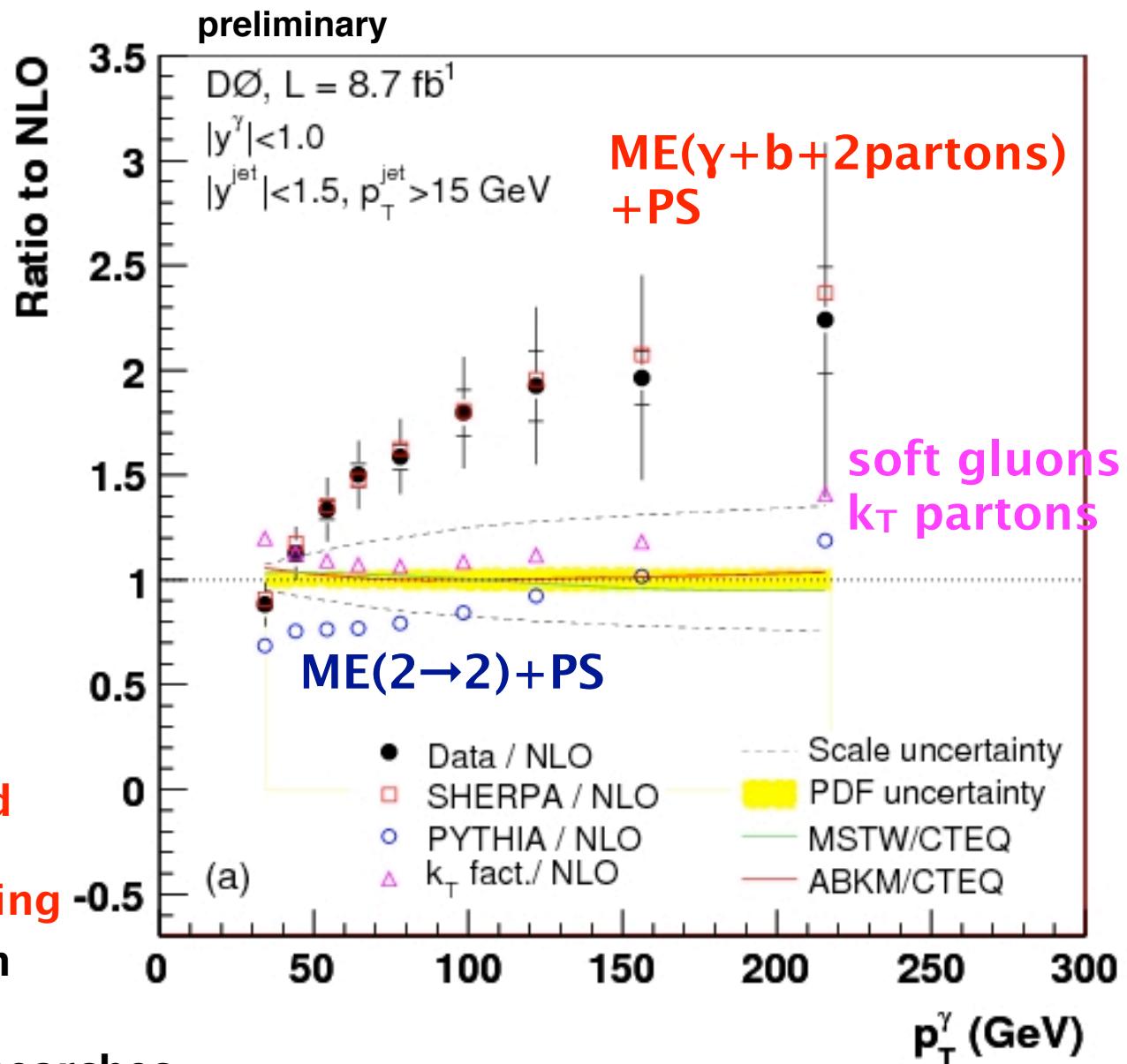
- direct photons come unaltered from hard subprocess:
→ direct probe of hard scattering
- sensitive to b quark and gluon densities
- background to NP and Higgs searches



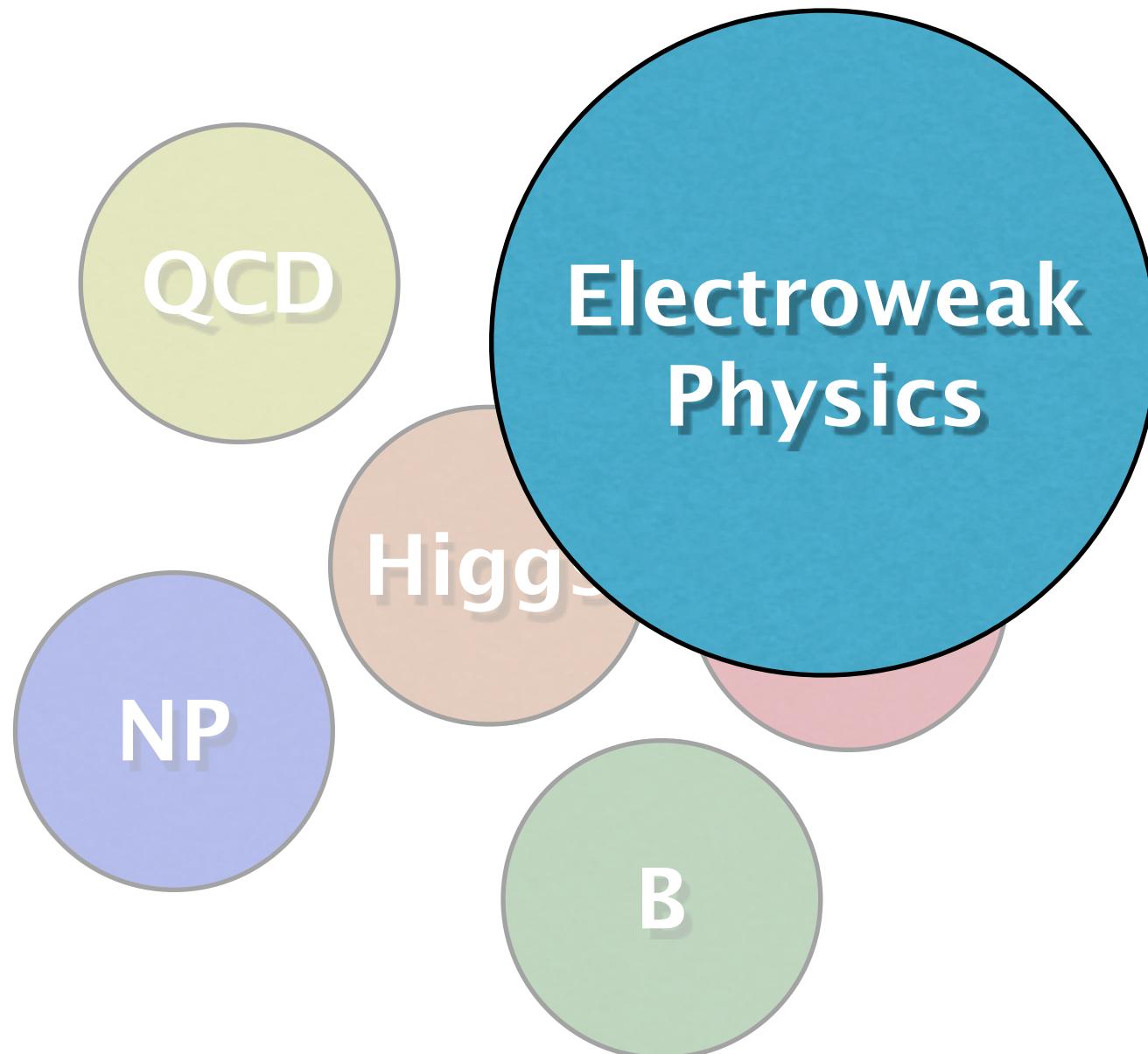
Photon+b-jet Cross Section



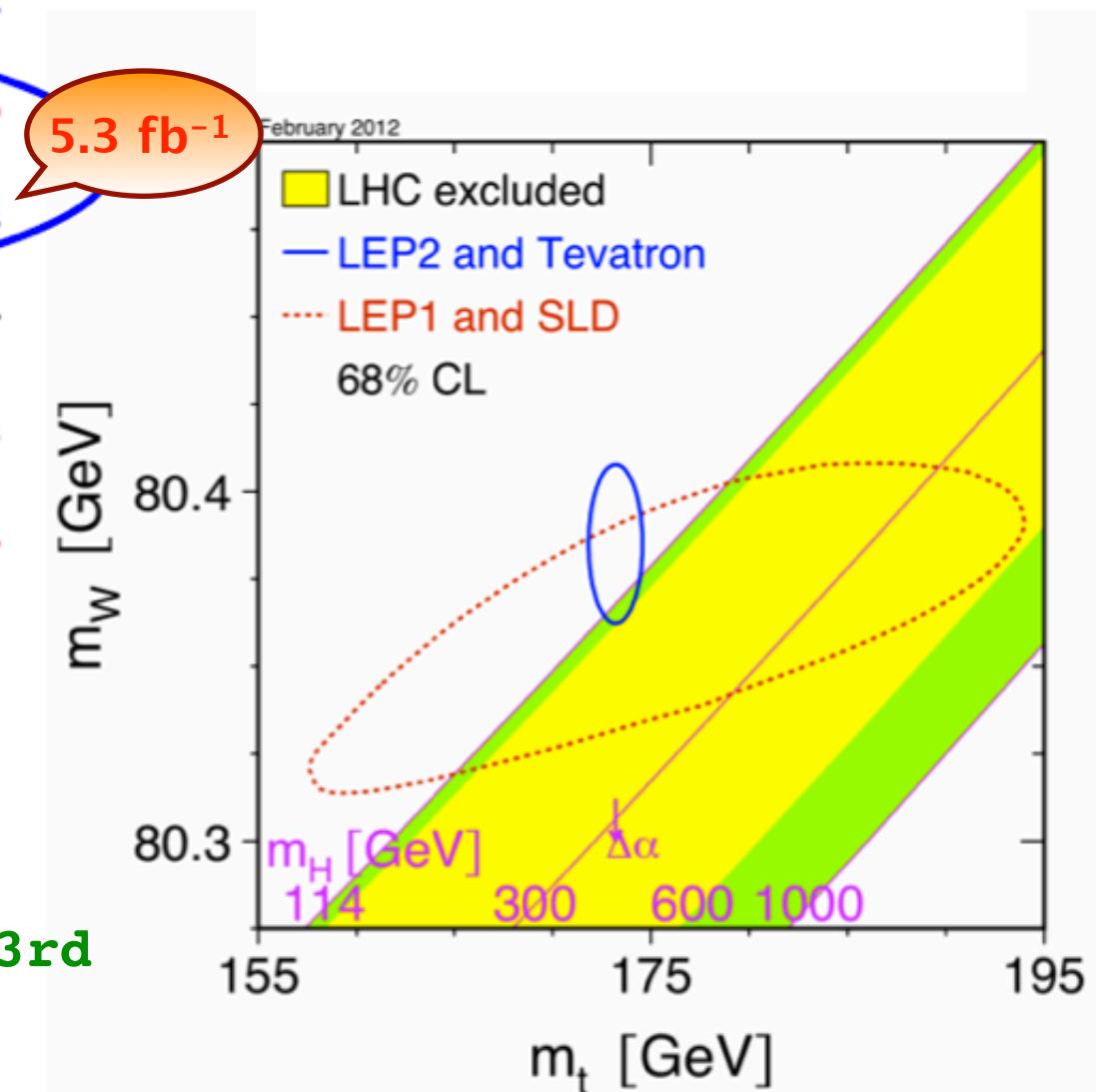
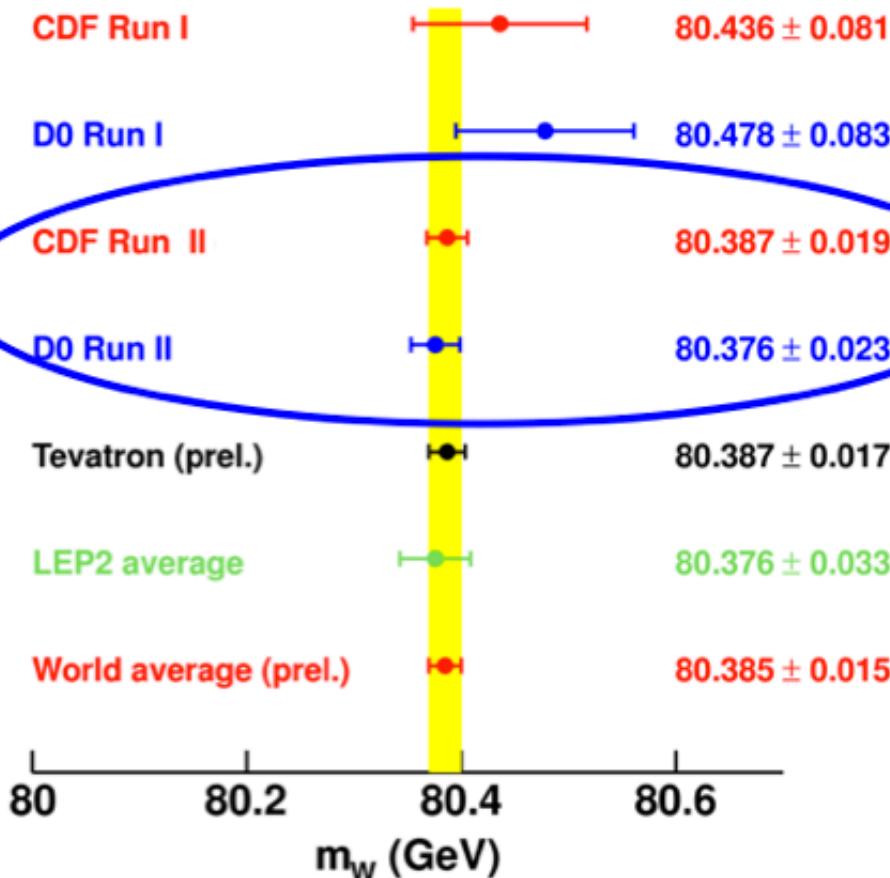
- direct photons come unaltered from hard subprocess:
→ direct probe of hard scattering
- sensitive to b quark and gluon densities
- background to NP and Higgs searches



DØ Physics Results for Winter 2012



W mass measurement

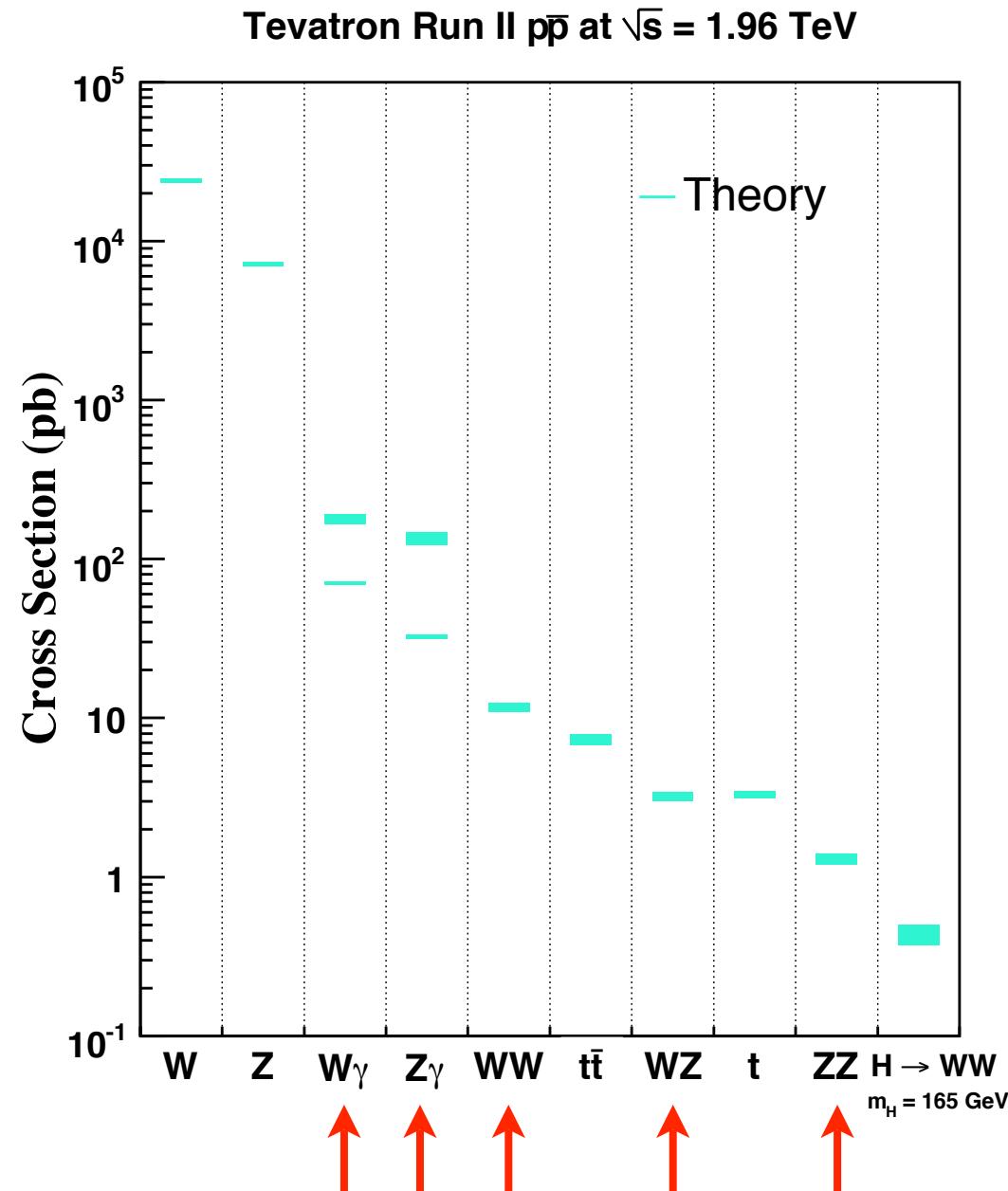


Ashutosh Kotwal, February 23rd

Jan Stark, March 1st

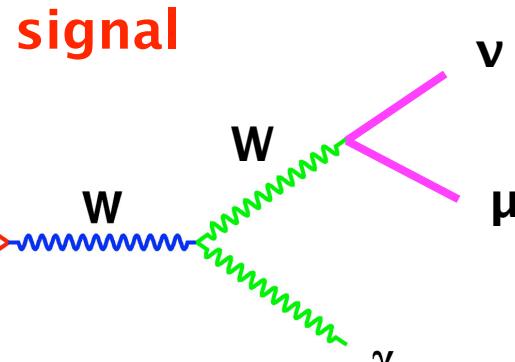
arXiv:1203.0293

Tevatron Cross Sections

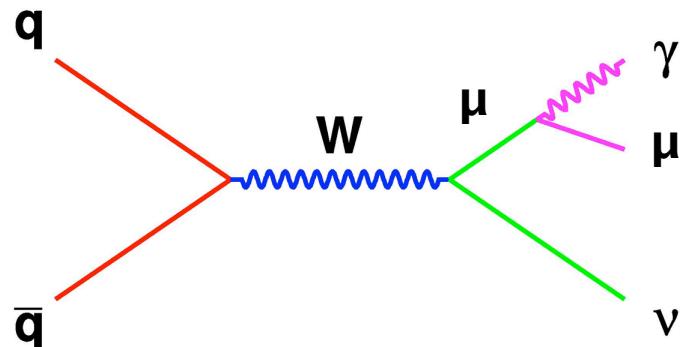


W γ Cross Section and WW γ Couplings

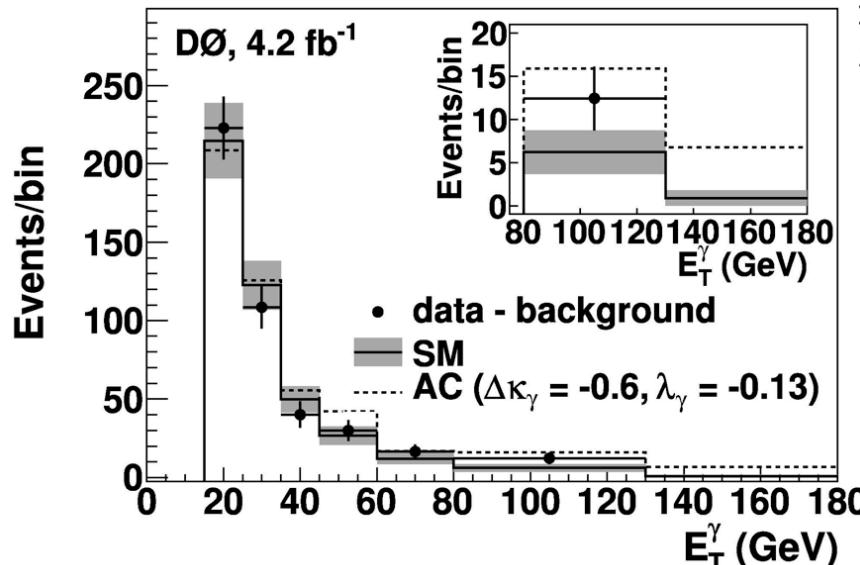
analyse non-abelian gauge structure



background



background rejection:
tight cut on transverse mass $M_T(\mu, \gamma, \text{MET})$

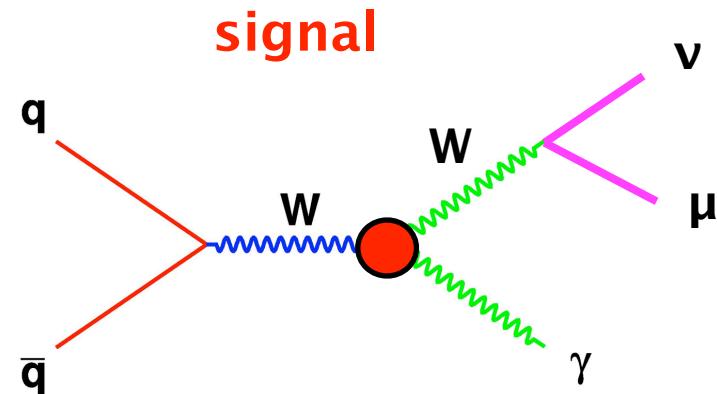


Phys. Rev. Lett. 107,
241803 (2011)

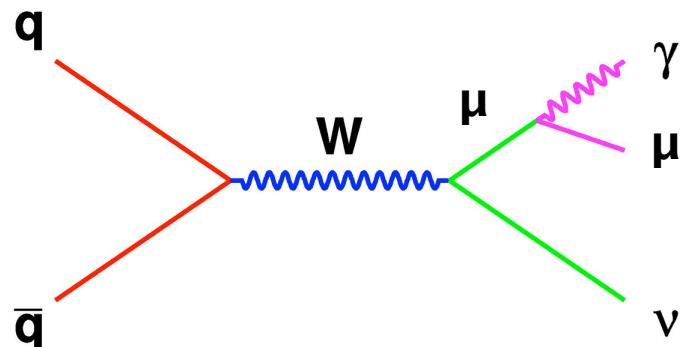
cross section
in agreement
with SM

W γ Cross Section and WW γ Couplings

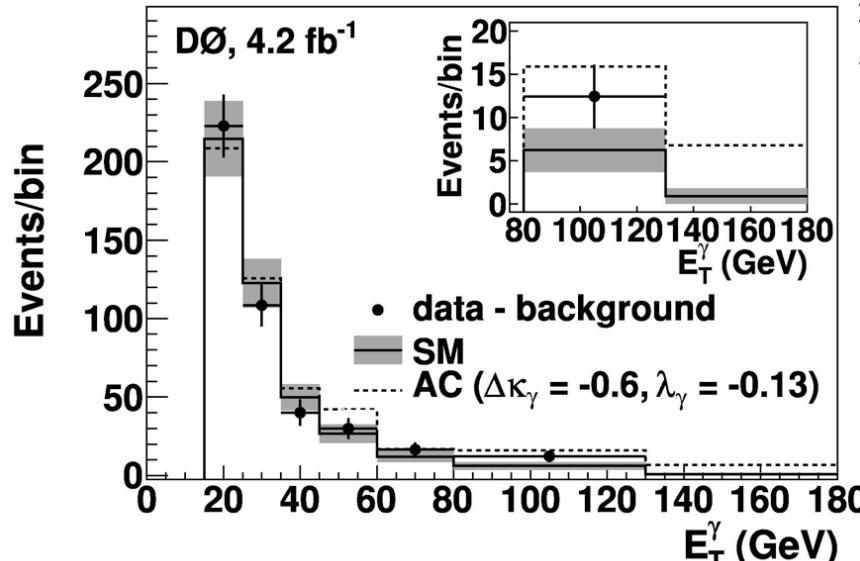
analyse non-abelian gauge structure



background



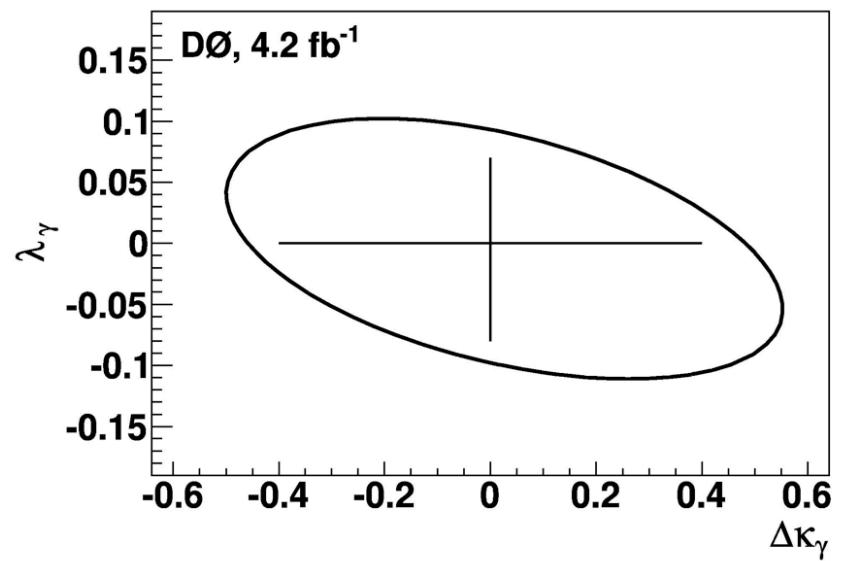
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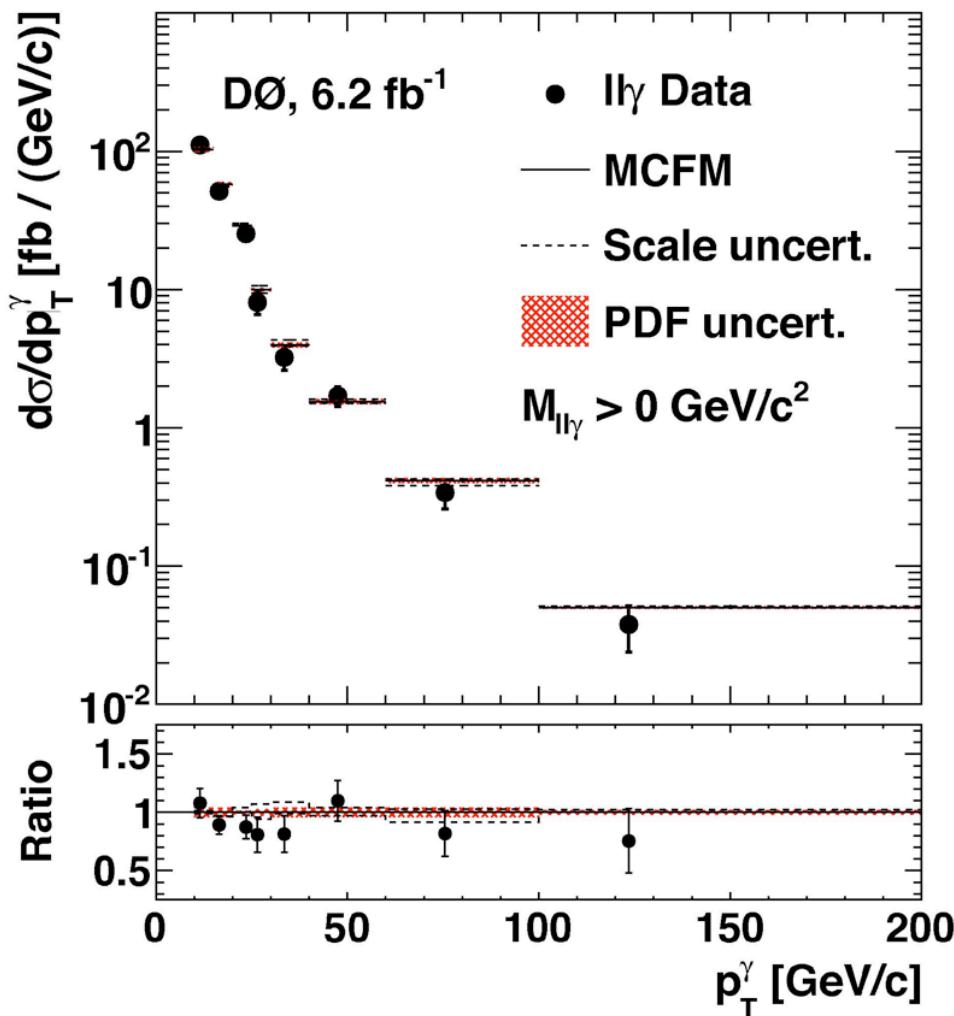
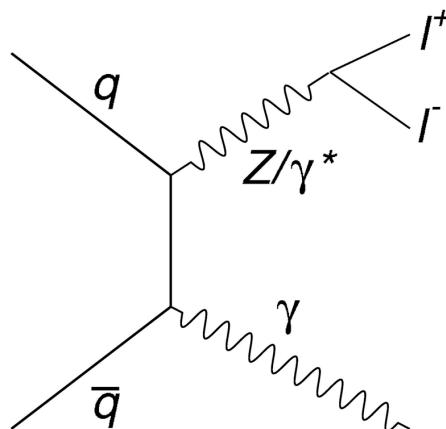
Phys. Rev. Lett. 107,
241803 (2011)

cross section
in agreement
with SM

strongest
limits on
anomalous
couplings
from Tevatron



Z γ Cross Section and ZZ γ , Z $\gamma\gamma$ Couplings



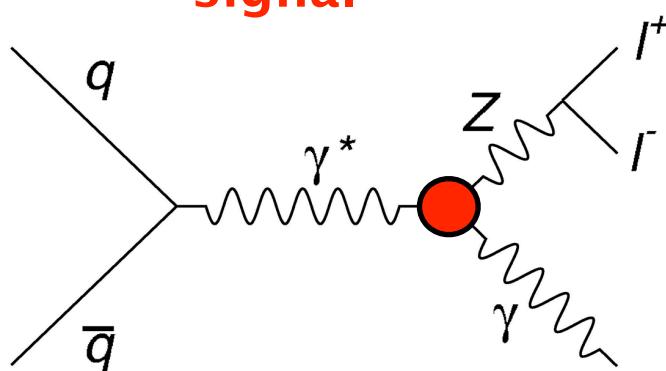
Phys. Rev. D 85,
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**cross section
in agreement
with SM**

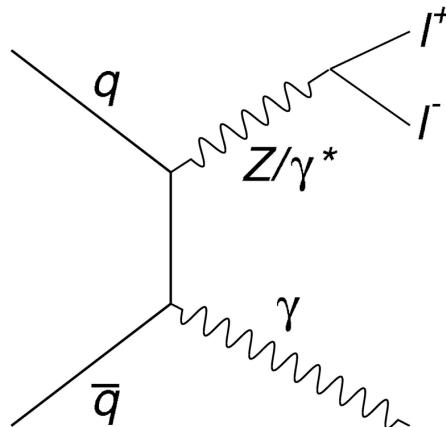
Z γ Cross Section and ZZ γ , Z $\gamma\gamma$ Couplings

analyse non-abelian gauge structure

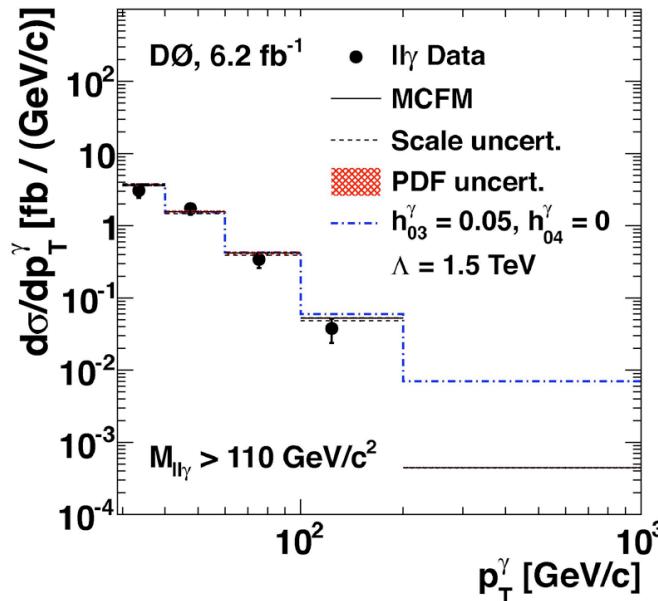
signal



background



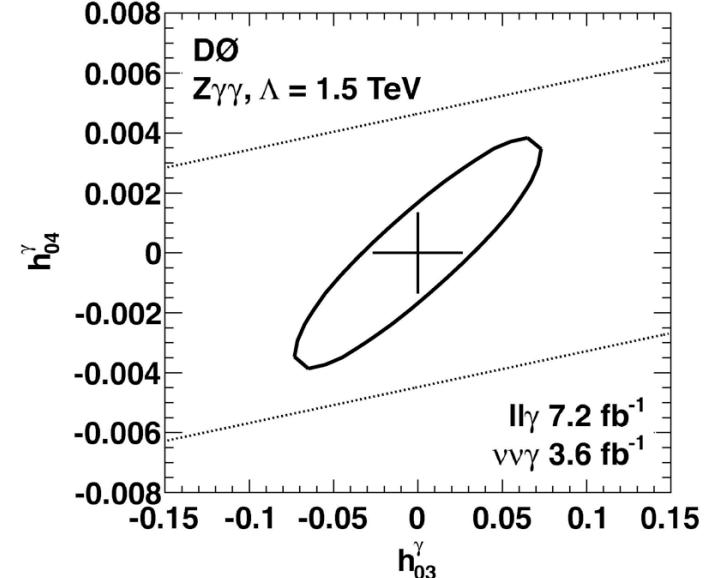
background rejection:
tight cut on invariant mass $M(\ell^+, \ell^-, \gamma)$



no hint for
anomalous
couplings

Phys. Rev. D 85,
052001 (2012)

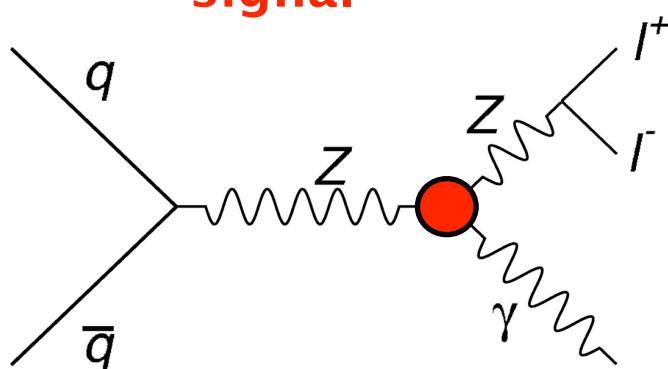
cross section
in agreement
with SM



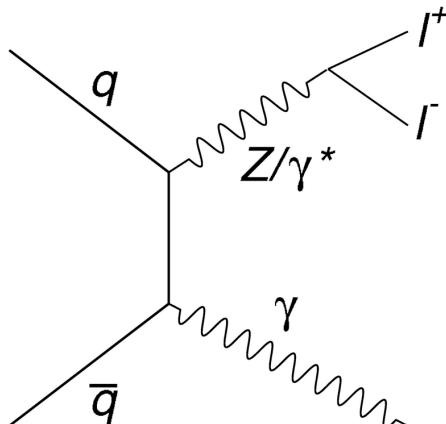
Z γ Cross Section and ZZ γ , Z $\gamma\gamma$ Couplings

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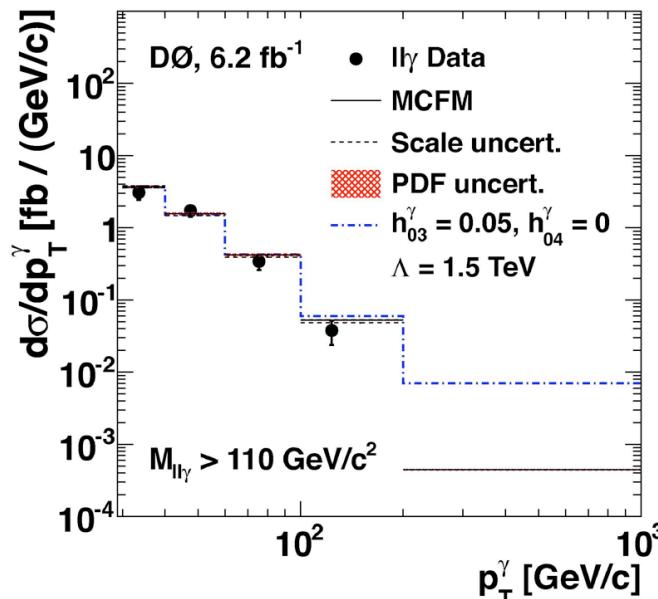
signal



background



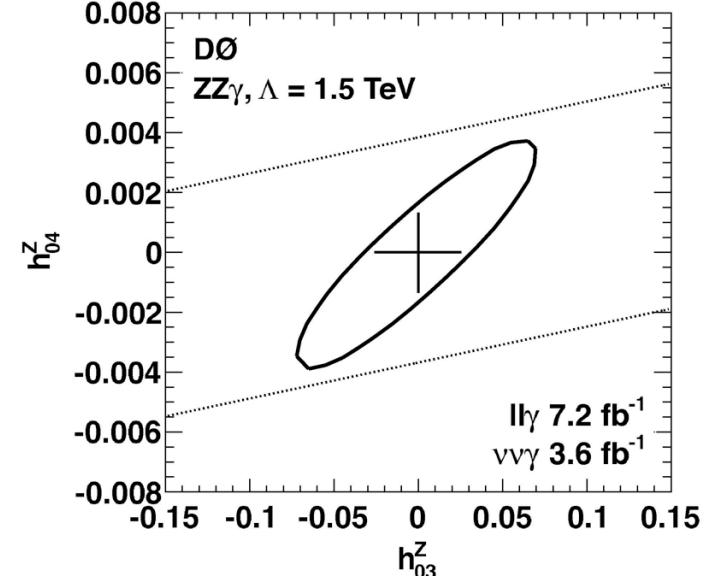
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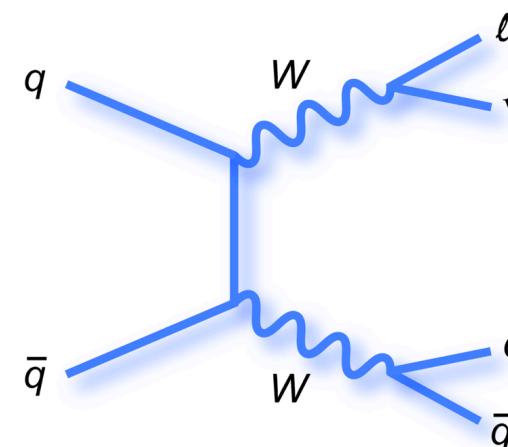
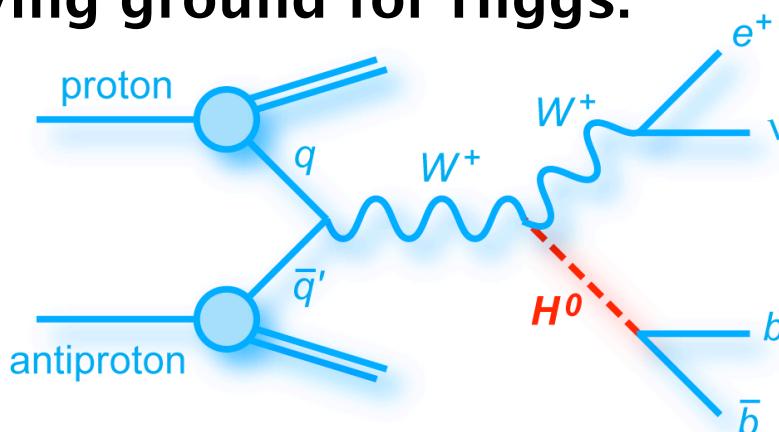
Phys. Rev. D 85,
052001 (2012)

cross section
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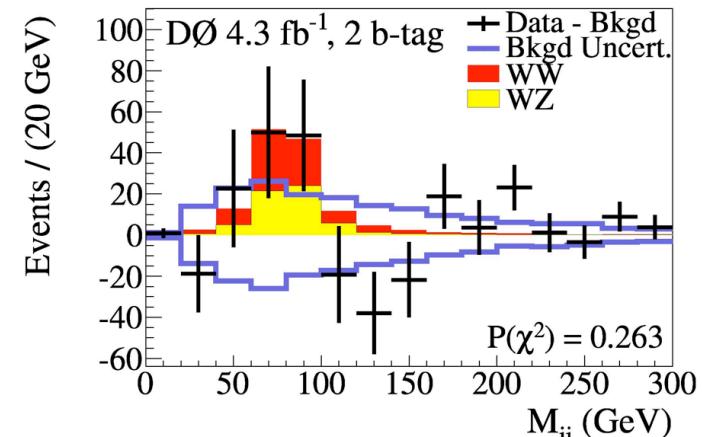
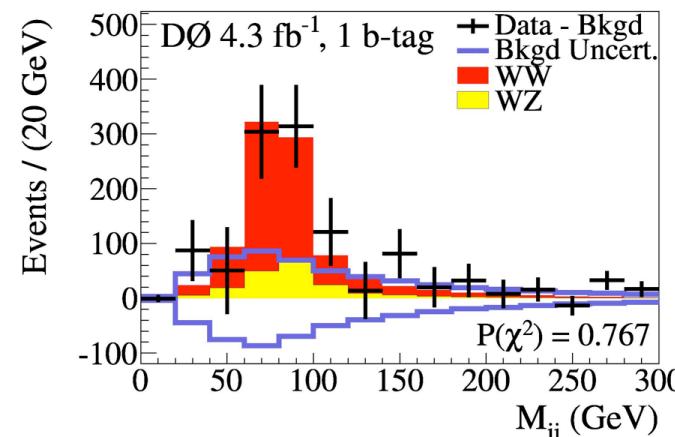
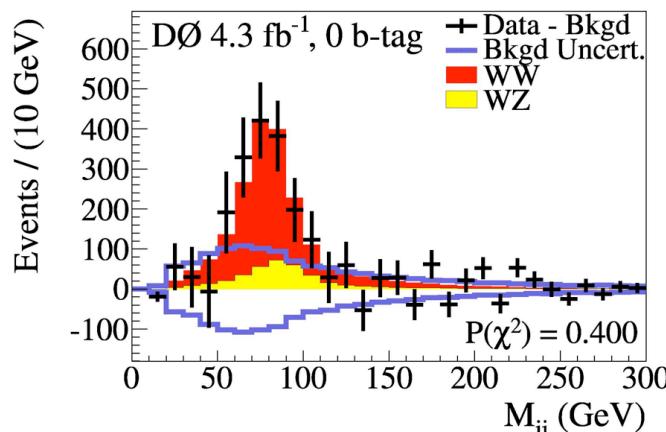


WW Cross Section

proving ground for Higgs:



arXiv:1112.0536 [hep-ex]

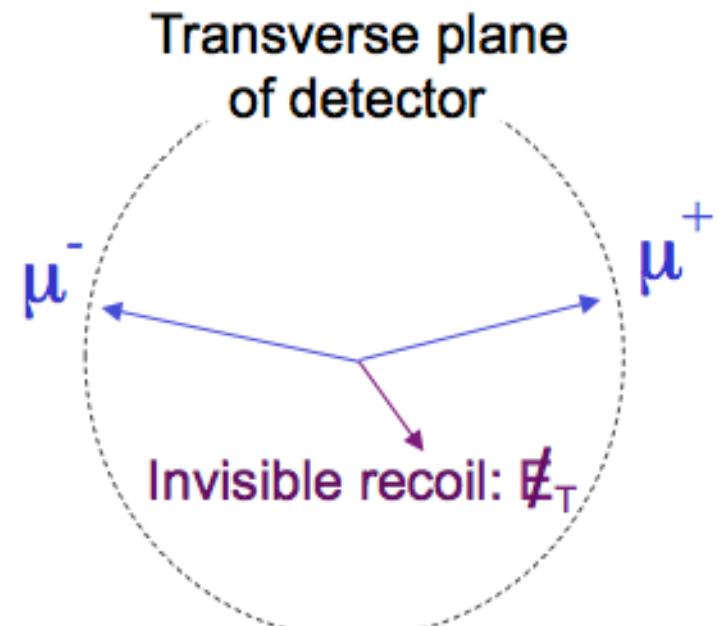
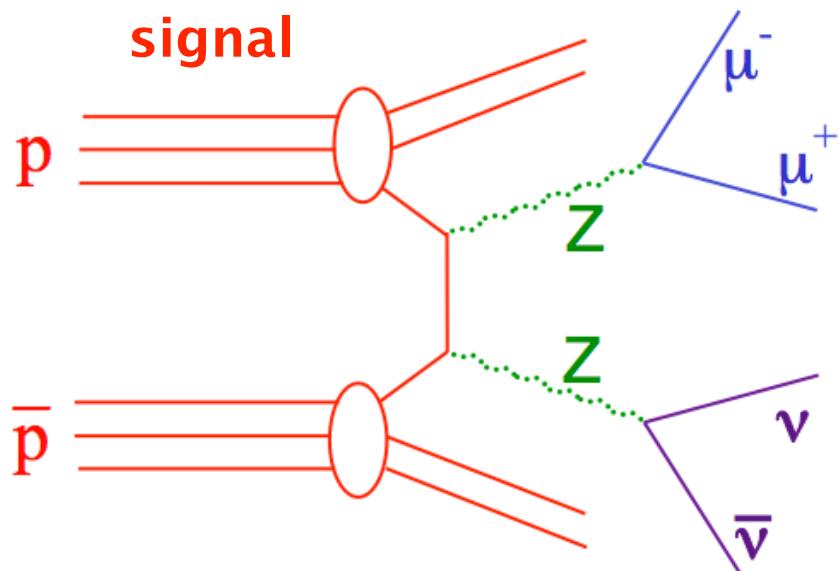


Satish Desai,
March 7,
Ken Herner,
December 9

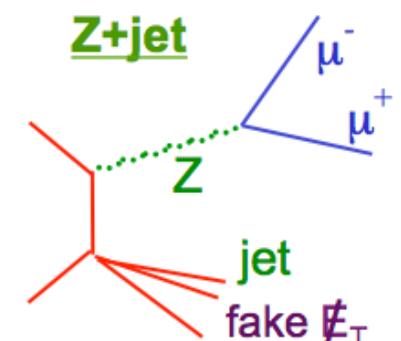
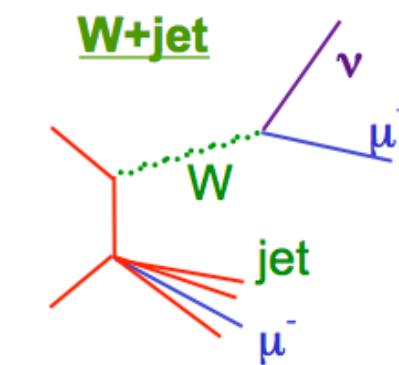
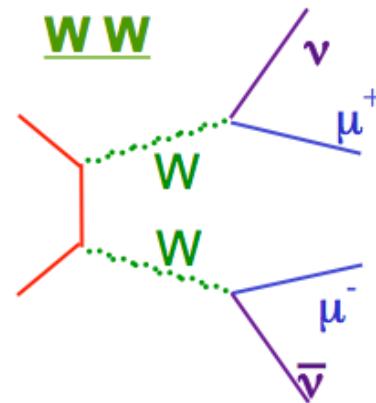
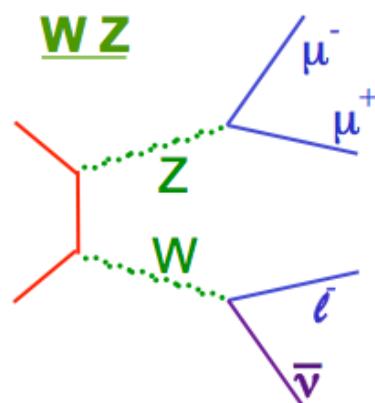
$$\sigma(WW) = 15.9^{+3.7}_{-3.2} \text{ pb}$$

→ good agreement with the SM

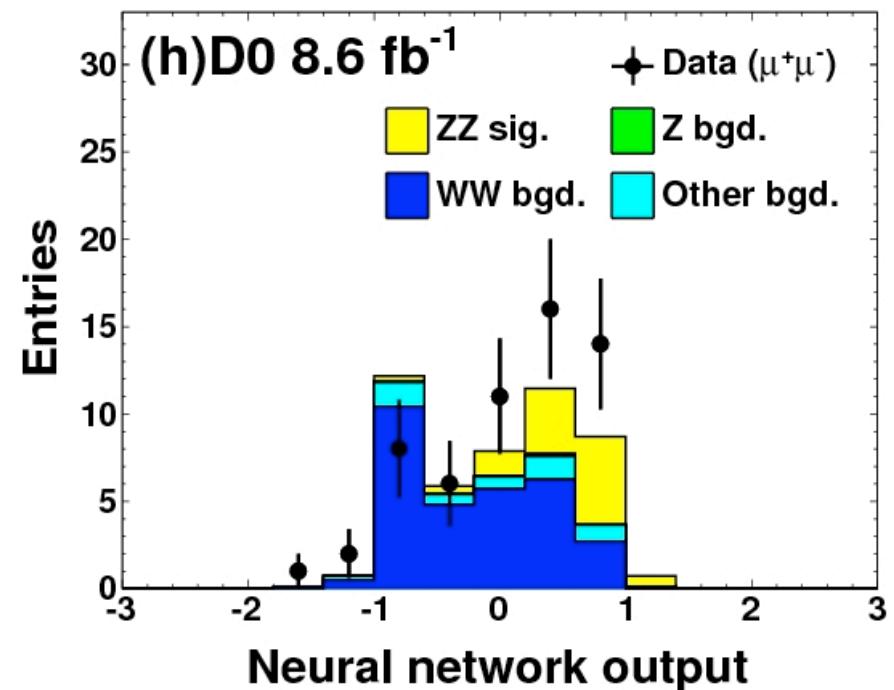
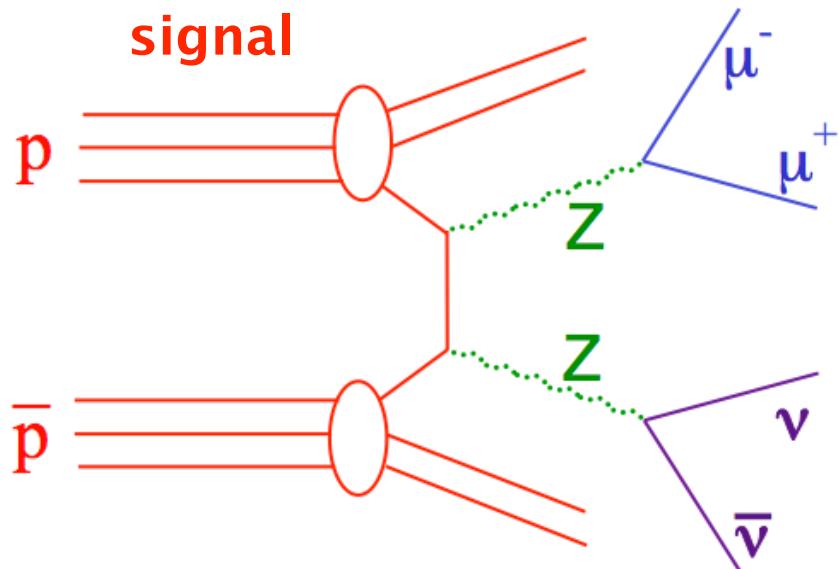
$ZZ \rightarrow \ell^+ \ell^- \nu \bar{\nu}$ Cross Section



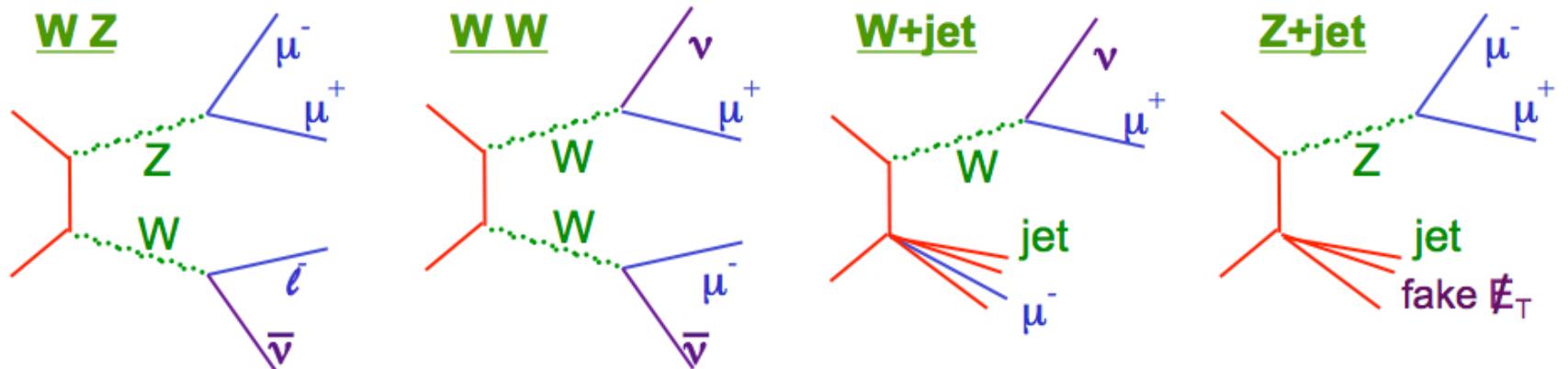
backgrounds



$ZZ \rightarrow \ell^+ \ell^- \nu \bar{\nu}$ Cross Section

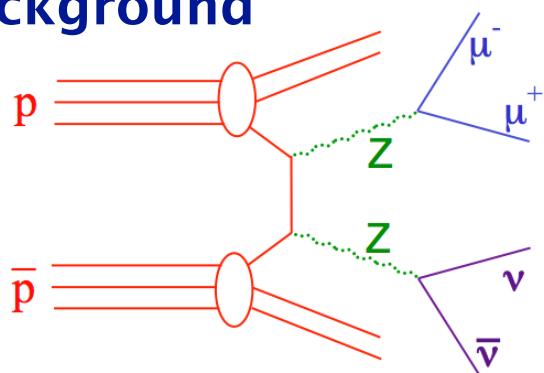


backgrounds

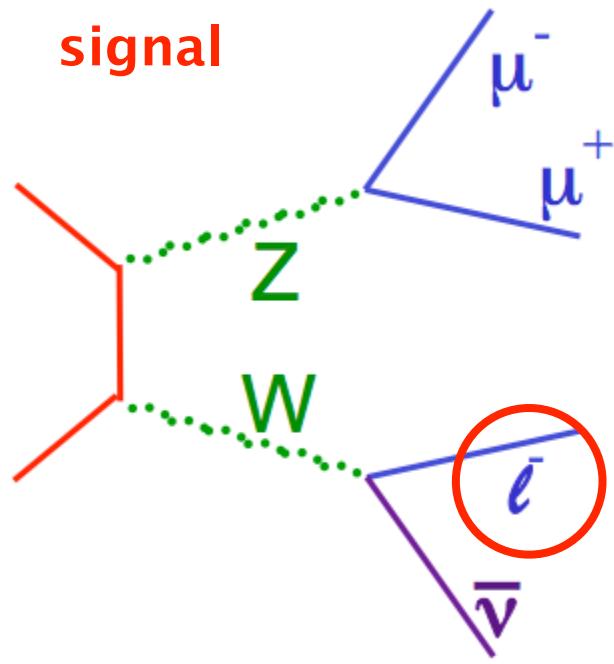


$WZ \rightarrow \ell^+ \ell^- \ell^\pm \nu$ Cross Section

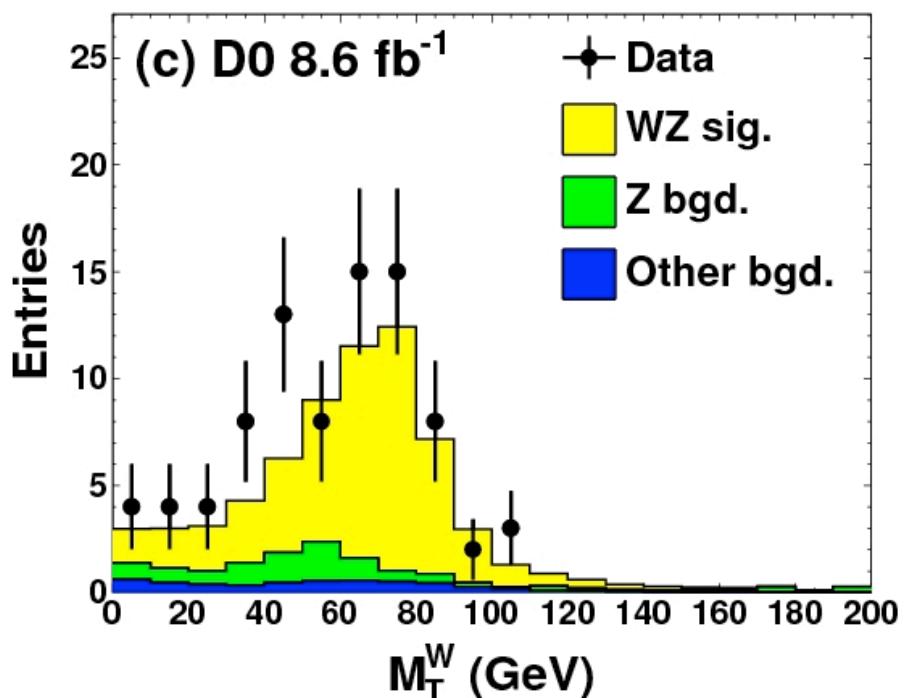
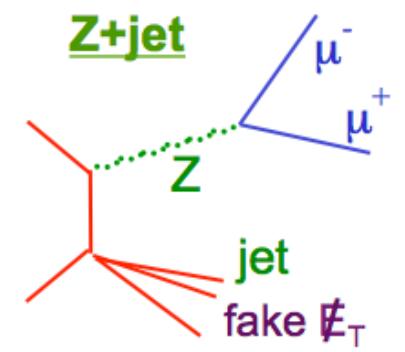
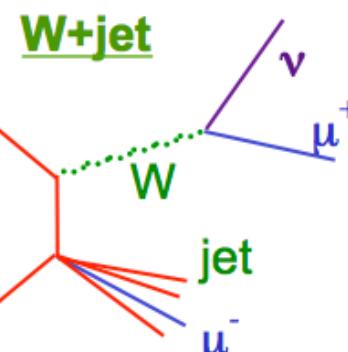
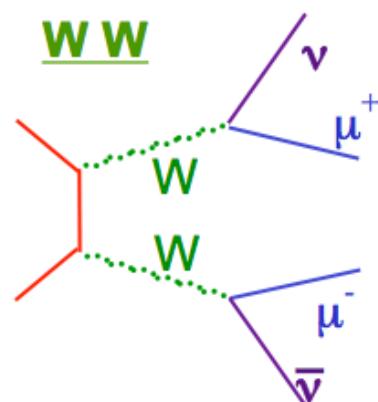
background



signal

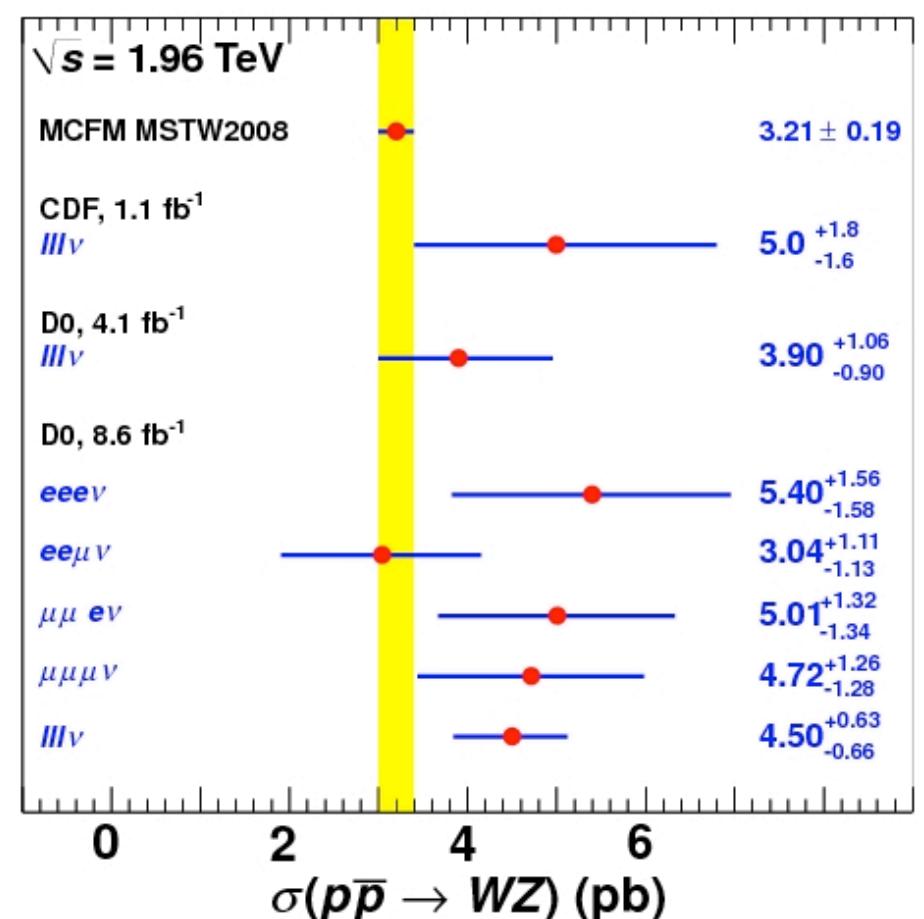
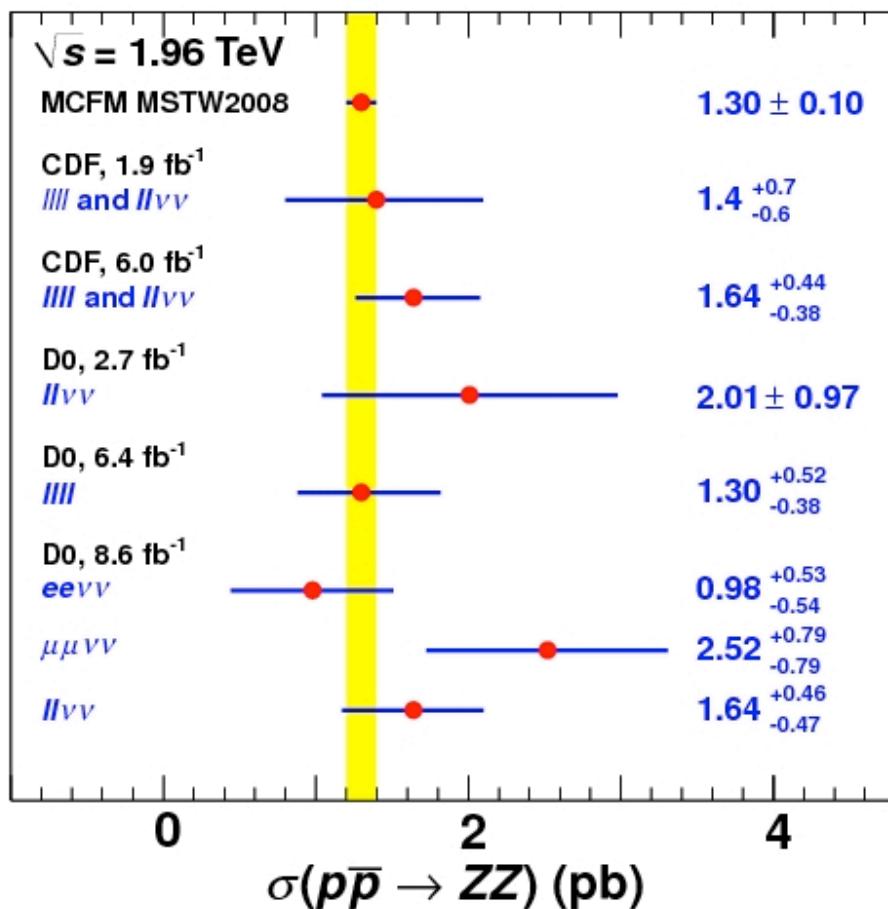


backgrounds



ZZ, WZ Cross Sections

measure ratio of ZZ/WZ over Z+jets cross section:

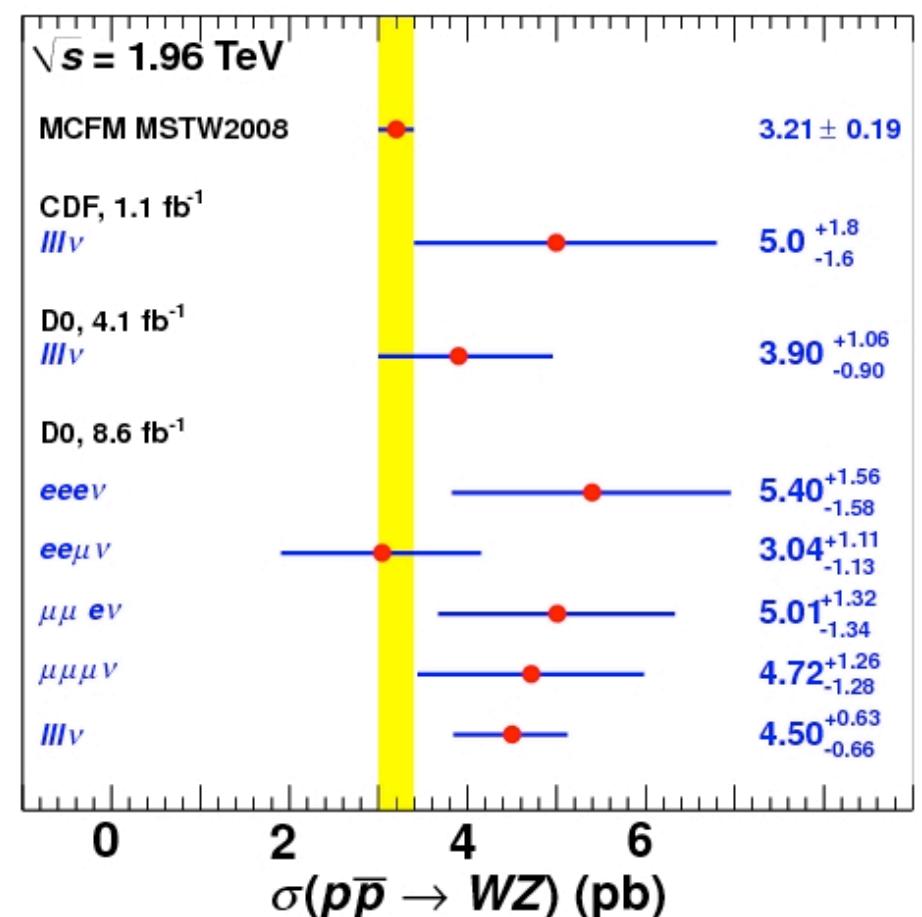
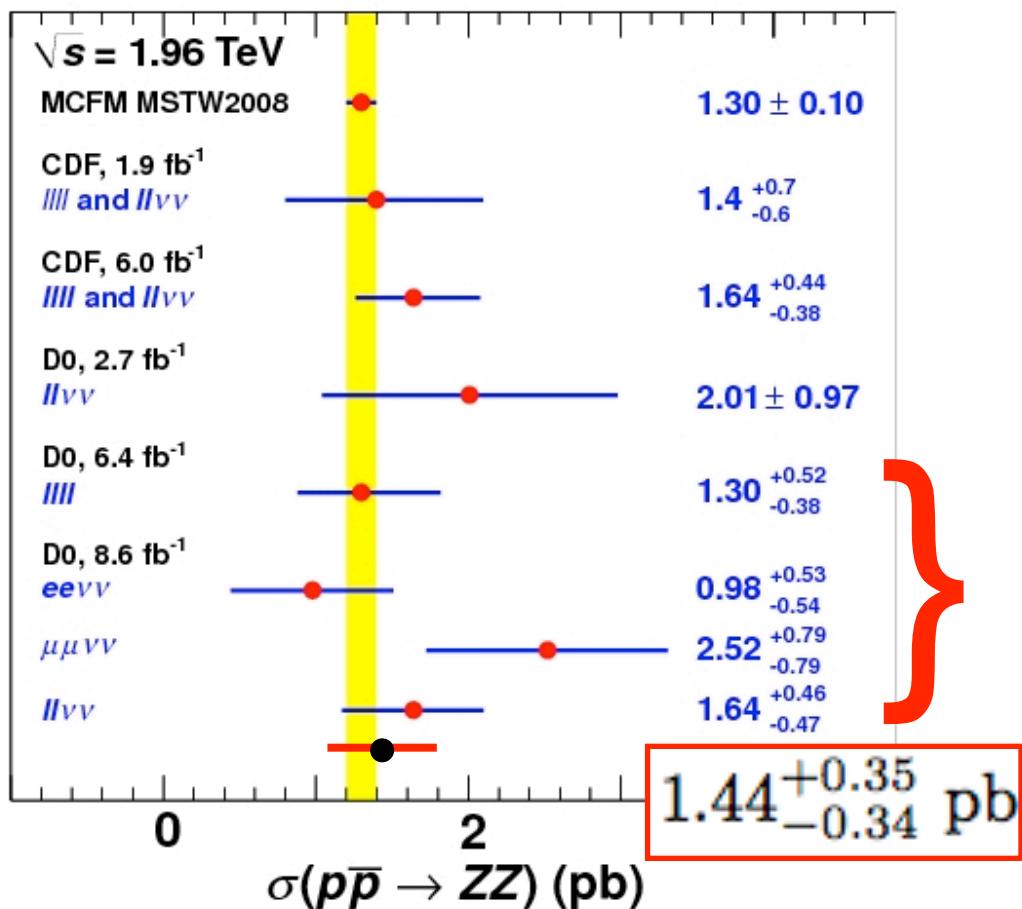


arXiv:1201.5652 [hep-ex]

→ good agreement with the SM

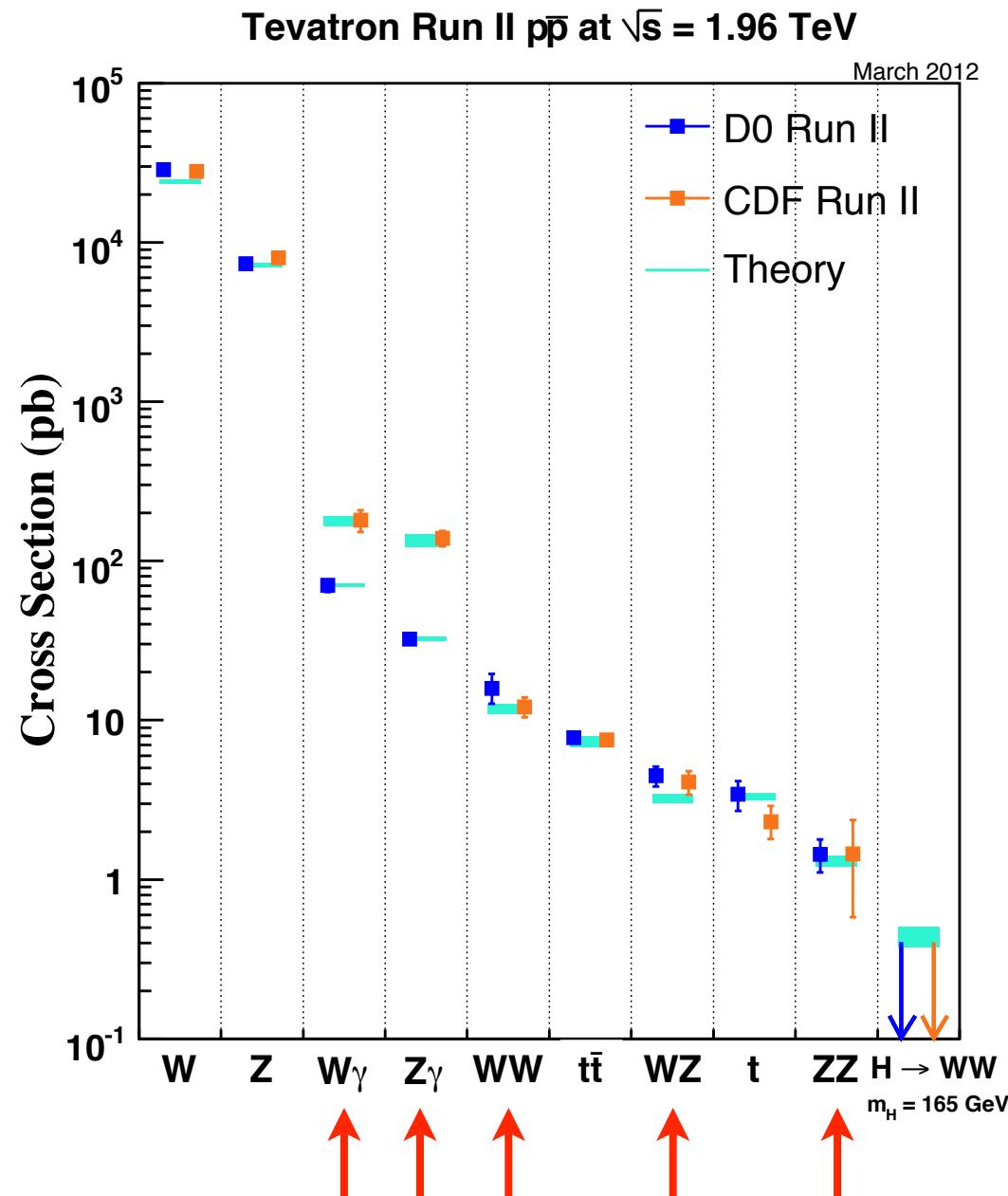
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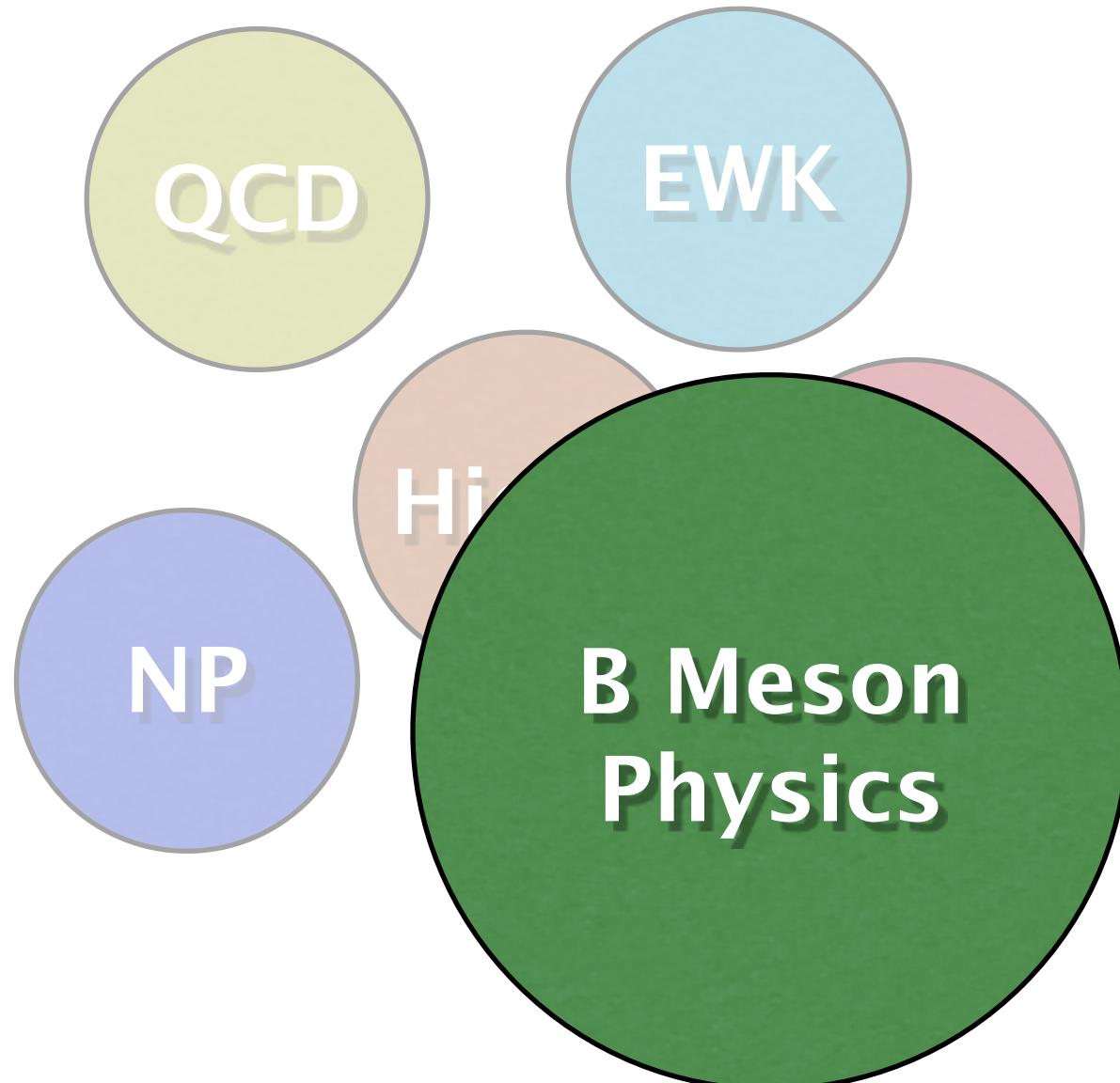


→ good agreement with the SM

Tevatron Cross Sections

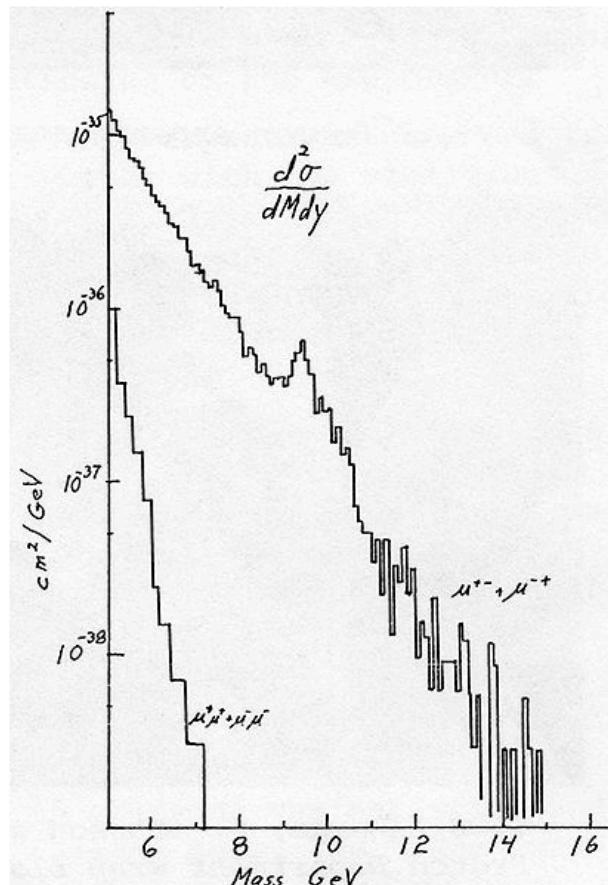


DØ Physics Results for Winter 2012



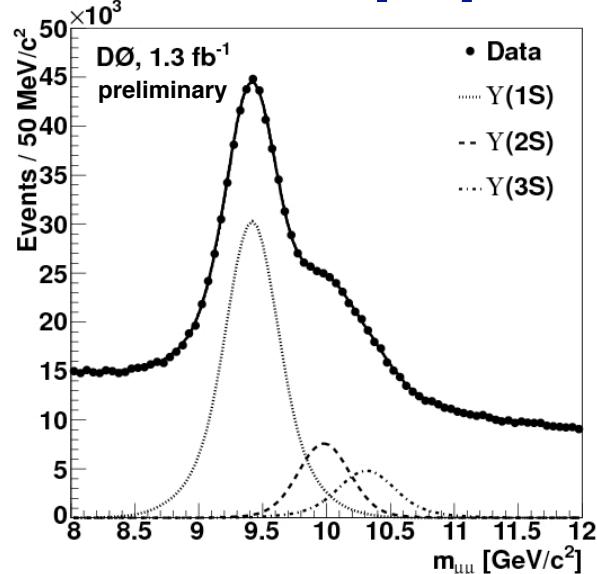
New Narrow Mass State Decaying into $\gamma(1S) + \gamma$

Υ discovery:
E288 collaboration

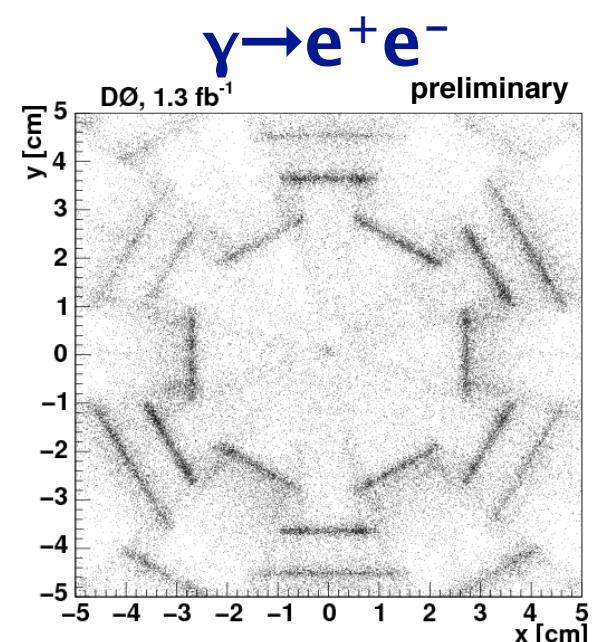
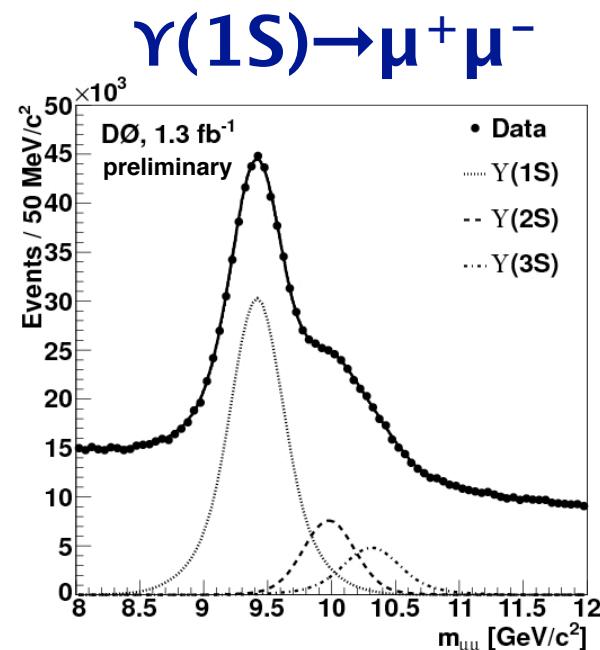


New Narrow Mass State Decaying into $\gamma(1S) + \gamma$

$\gamma(1S) \rightarrow \mu^+ \mu^-$

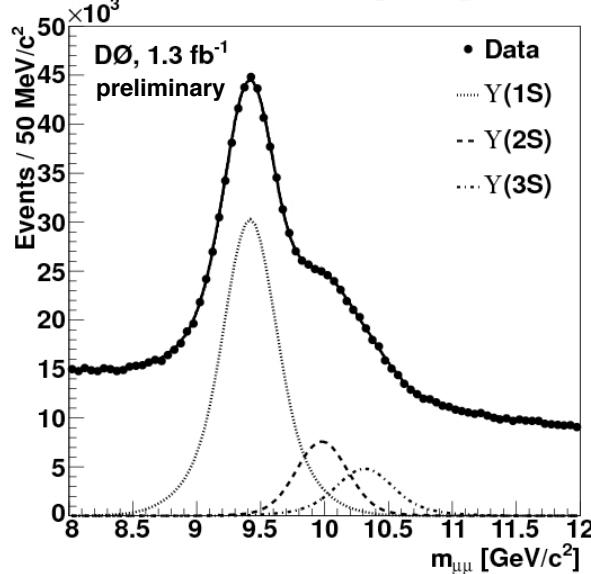


New Narrow Mass State Decaying into $\gamma(1S) + \gamma$

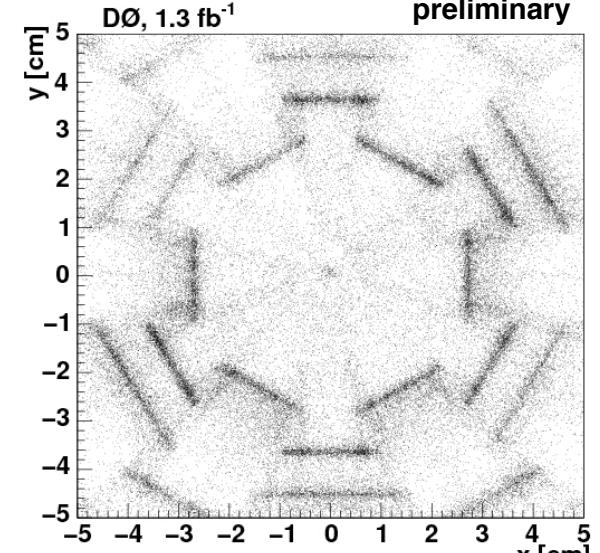


New Narrow Mass State Decaying into $\gamma(1S) + \gamma$

$\gamma(1S) \rightarrow \mu^+ \mu^-$



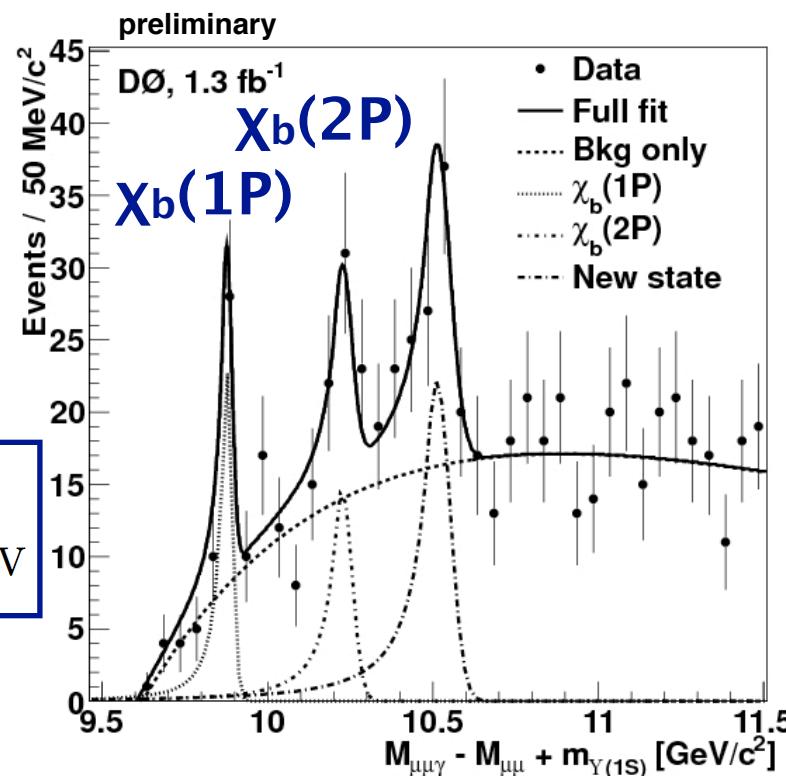
$\gamma \rightarrow e^+ e^-$



ATLAS:

$X_b(3P)$:

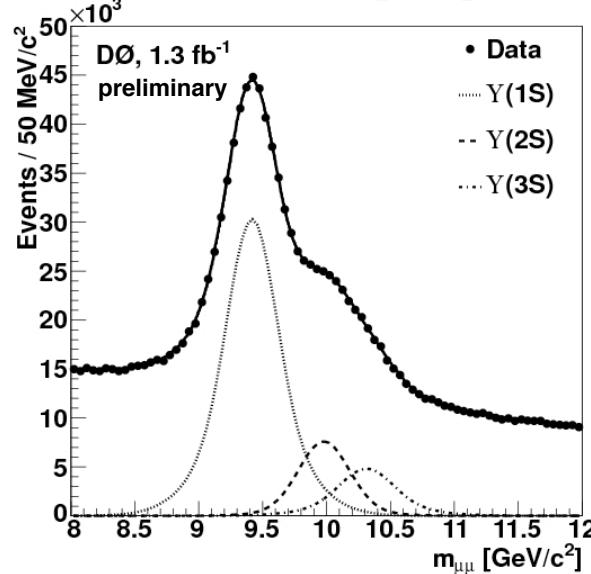
$10.530 \pm 0.005(\text{stat.}) \pm 0.009(\text{syst.}) \text{ GeV}$



background model:
combine $\gamma(1S)$ with
photons from
different events

New Narrow Mass State Decaying into $\gamma(1S) + \gamma$

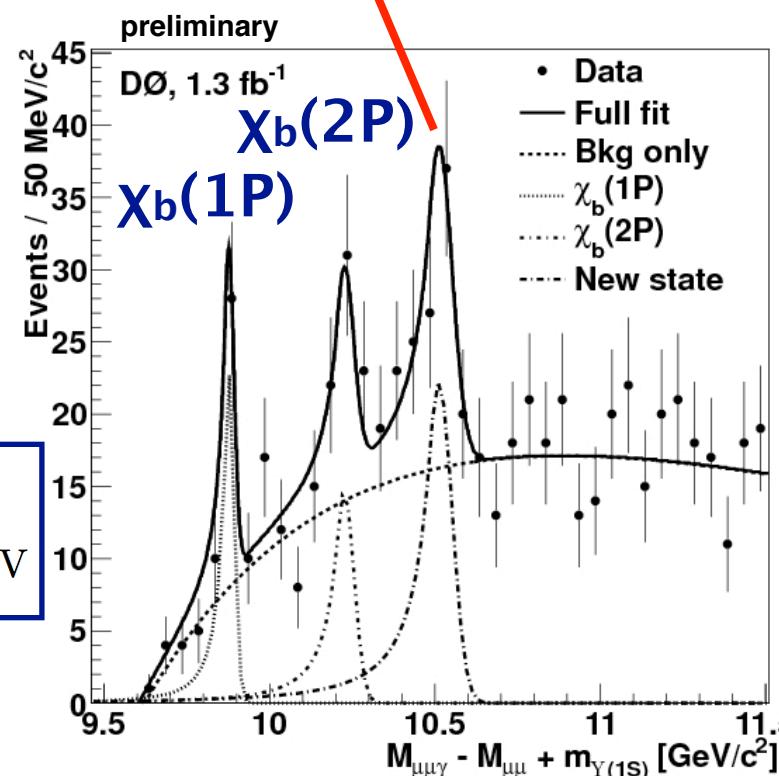
$\gamma(1S) \rightarrow \mu^+ \mu^-$



X_b(3P) → $\gamma(1S) + \gamma$

X_b(3P): (?)

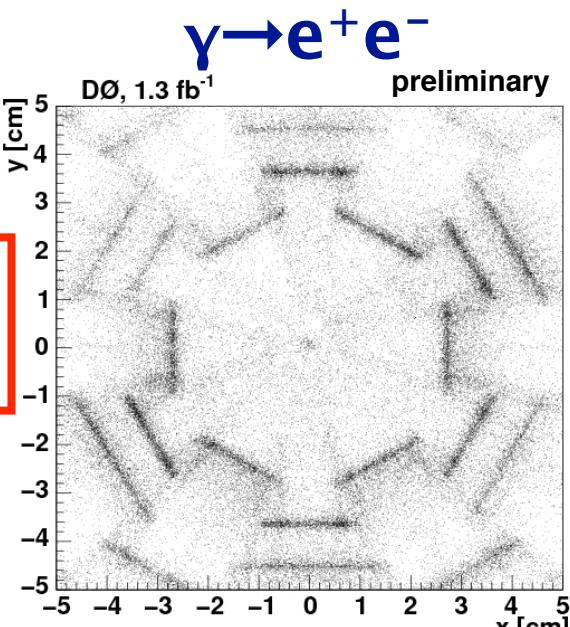
10.551 ± 0.014(stat.) ± 0.017(syst.) GeV



ATLAS:

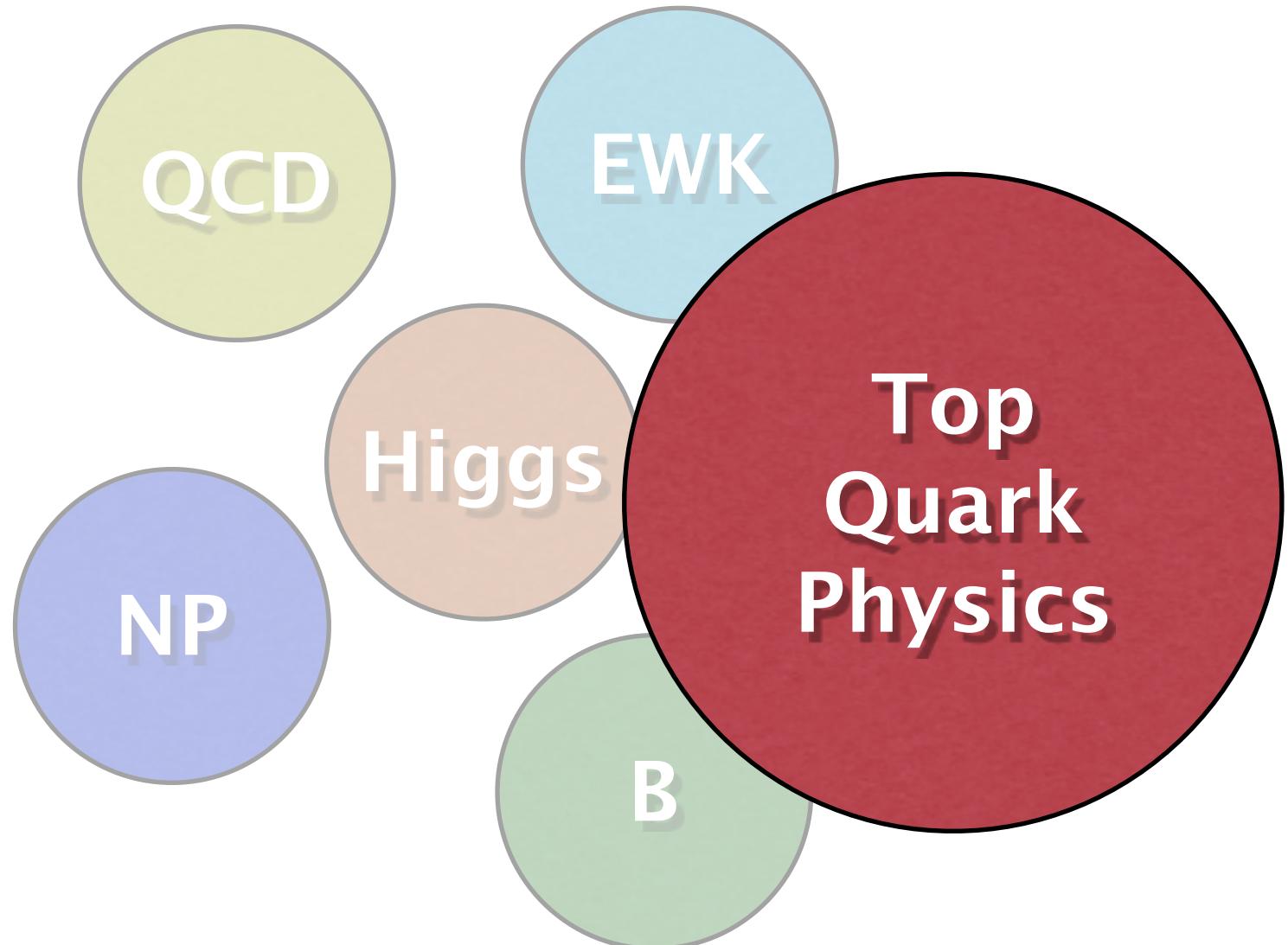
X_b(3P):

10.530 ± 0.005(stat.) ± 0.009(syst.) GeV



⇒ confirmation: 6σ
many more interesting measurements to do...

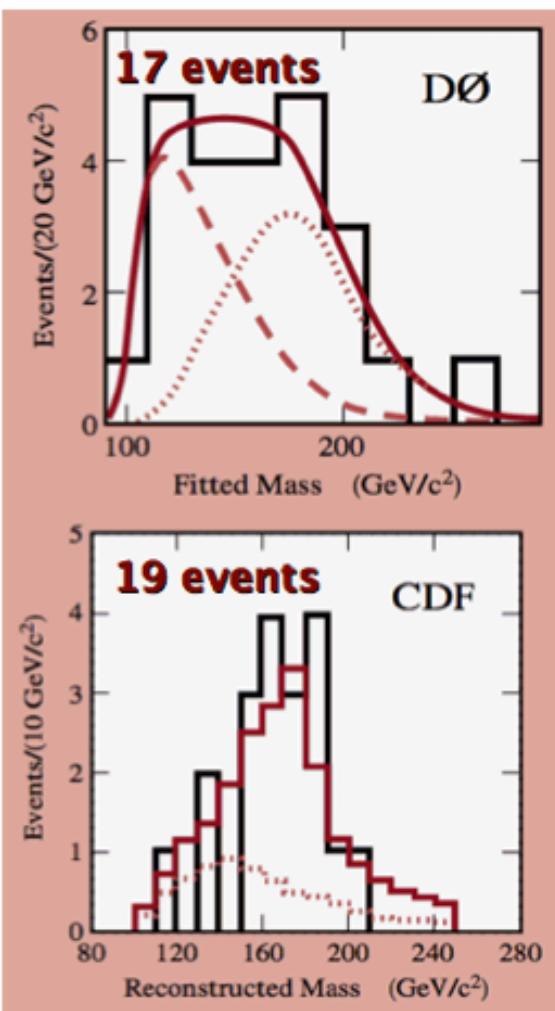
DØ Physics Results for Winter 2012



Top Quark

discovery

PRL 74, 2632 (1995)
PRL 74, 2626 (1995)



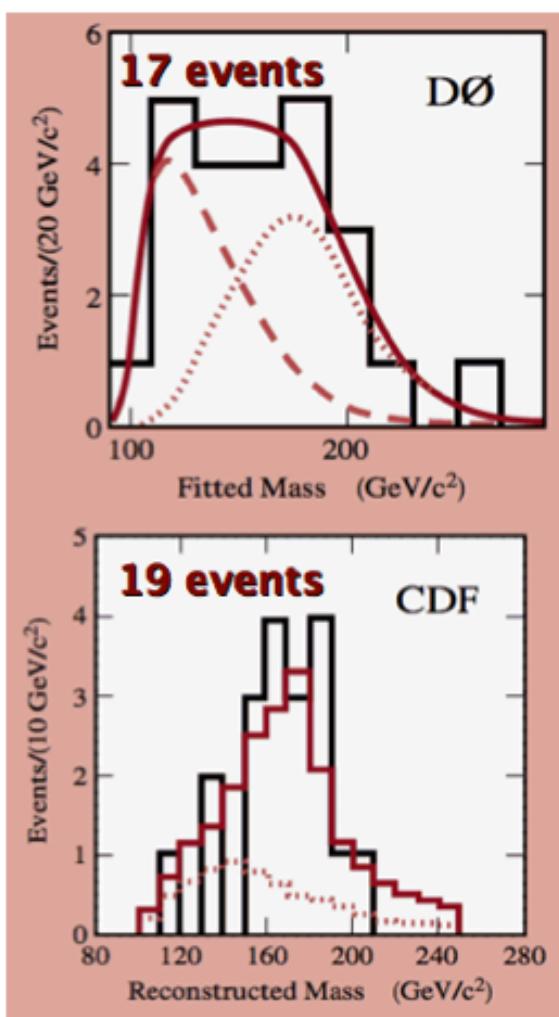
**1995, CDF and DØ
experiments, Fermilab**



Top Quark

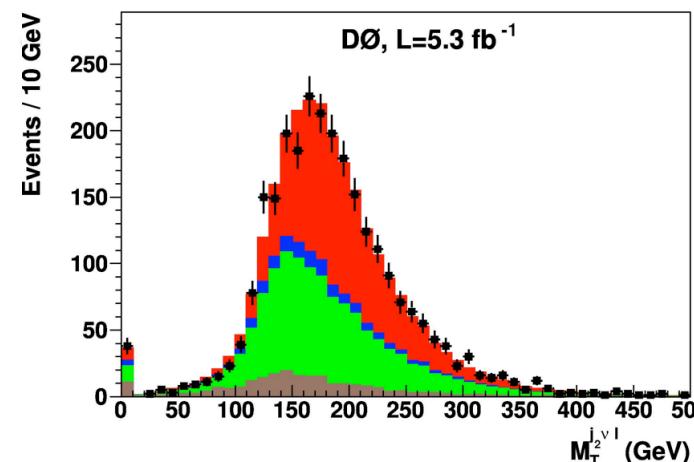
discovery

PRL 74, 2632 (1995)
PRL 74, 2626 (1995)



today

1000s of events

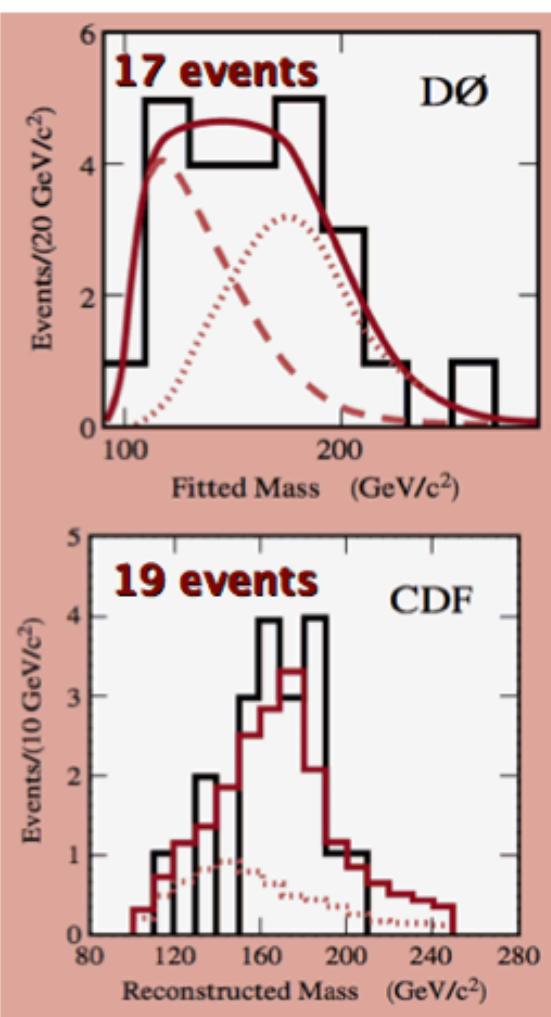


**1995, CDF and DØ
experiments, Fermilab**

Top Quark

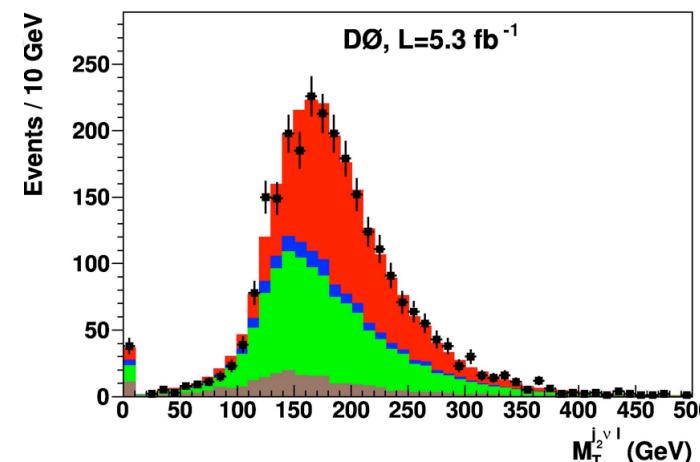
discovery

PRL 74, 2632 (1995)
PRL 74, 2626 (1995)



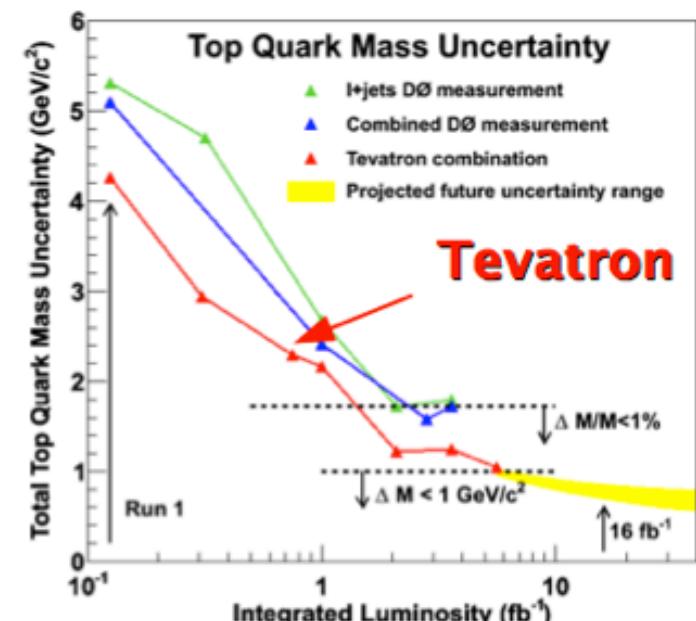
today

1000s of events



1995, CDF and DØ
experiments, Fermilab

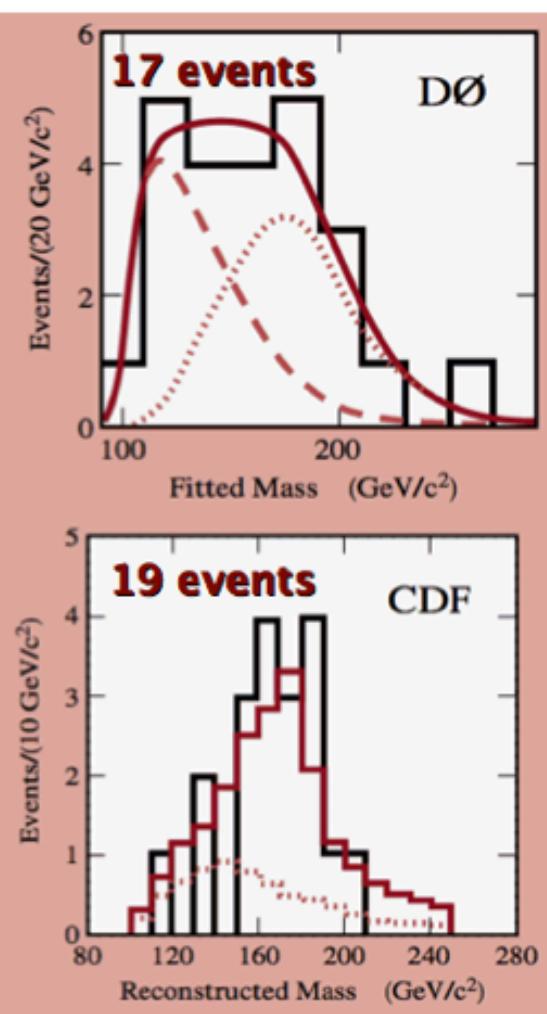
precision



Top Quark

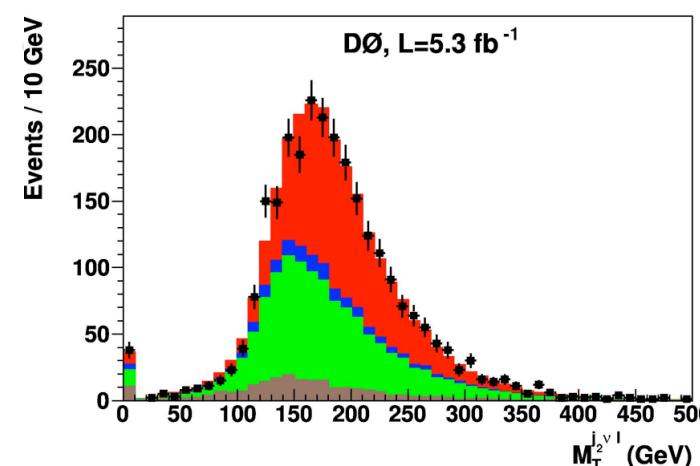
discovery

PRL 74, 2632 (1995)
PRL 74, 2626 (1995)



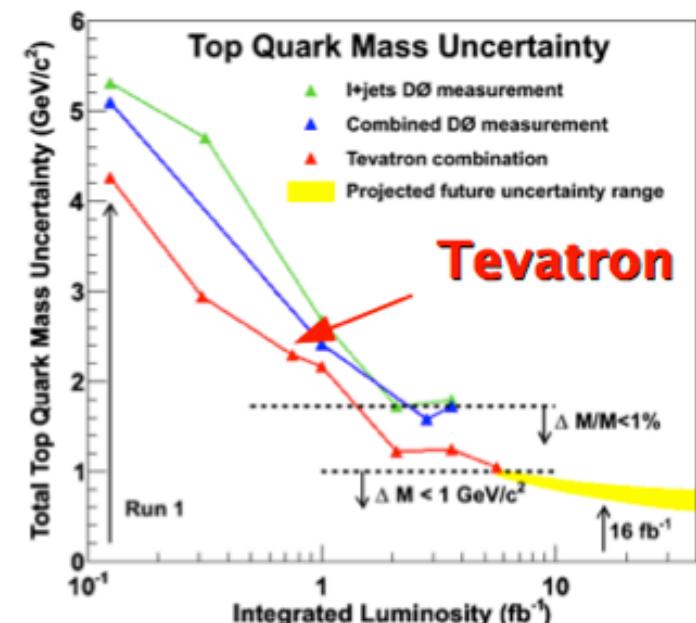
1995, CDF and DØ
experiments, Fermilab

today



hints &
excesses?

precision



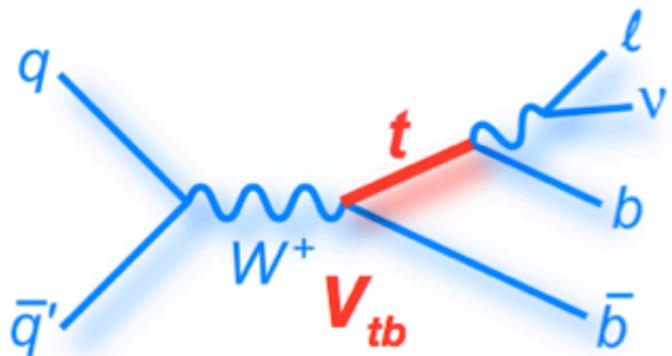
searches



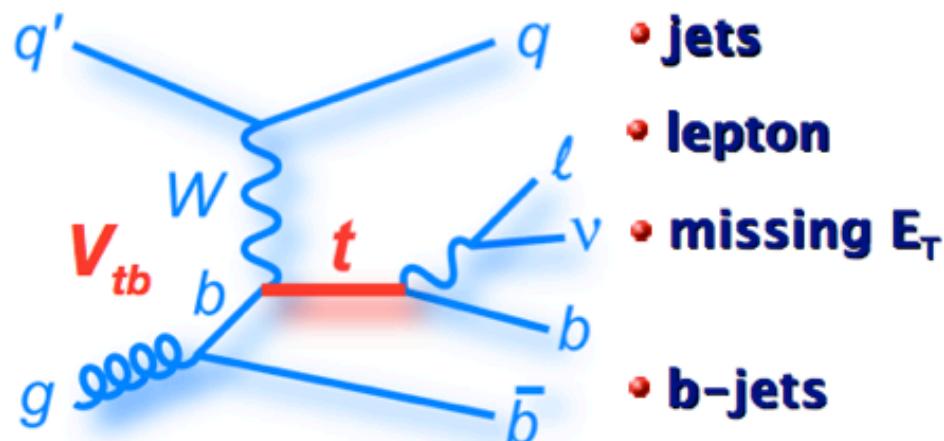
Single Top Quark Production

direct measurement of $|V_{tb}|$

s-channel:



t-channel:



Phys. Rev. D 84, 112001 (2011)

$$V_{CKM} = \begin{pmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{pmatrix}$$

Victor Bazterra, 10 February

$$\sigma(p\bar{p} \rightarrow tb + X) = 0.68^{+0.38}_{-0.35} \text{ pb}$$

$$\sigma(p\bar{p} \rightarrow tqb + X) = 2.86^{+0.69}_{-0.63} \text{ pb}$$

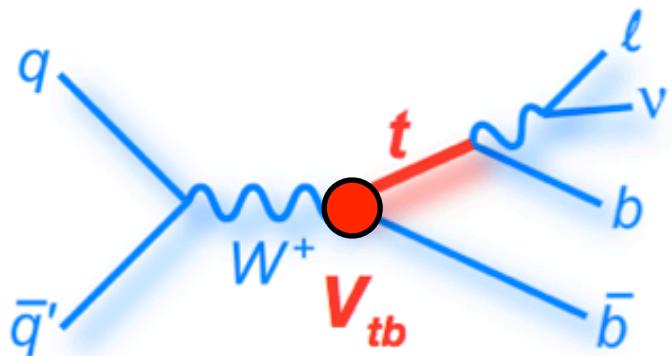
$$\sigma(p\bar{p} \rightarrow tb + tqb + X) = 3.43^{+0.73}_{-0.74} \text{ pb}$$

$$|V_{tb}| = 1.02^{+0.10}_{-0.11}$$

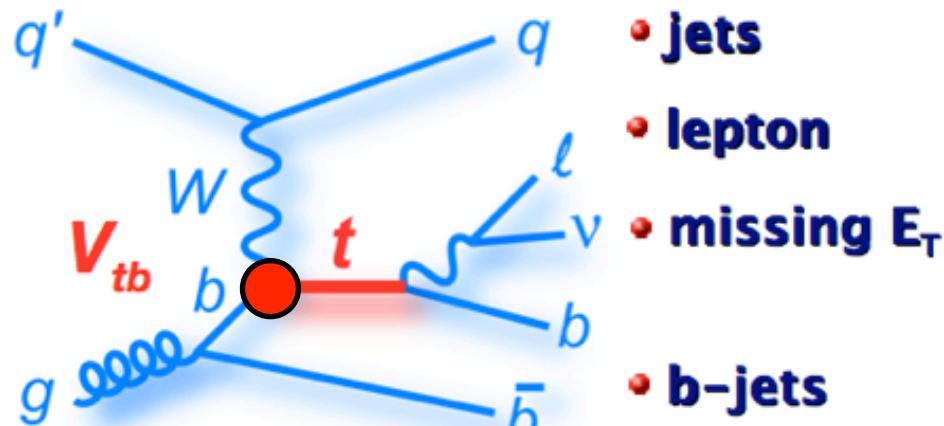
Single Top Quark Production

search for anomalous Wtb couplings

s-channel:

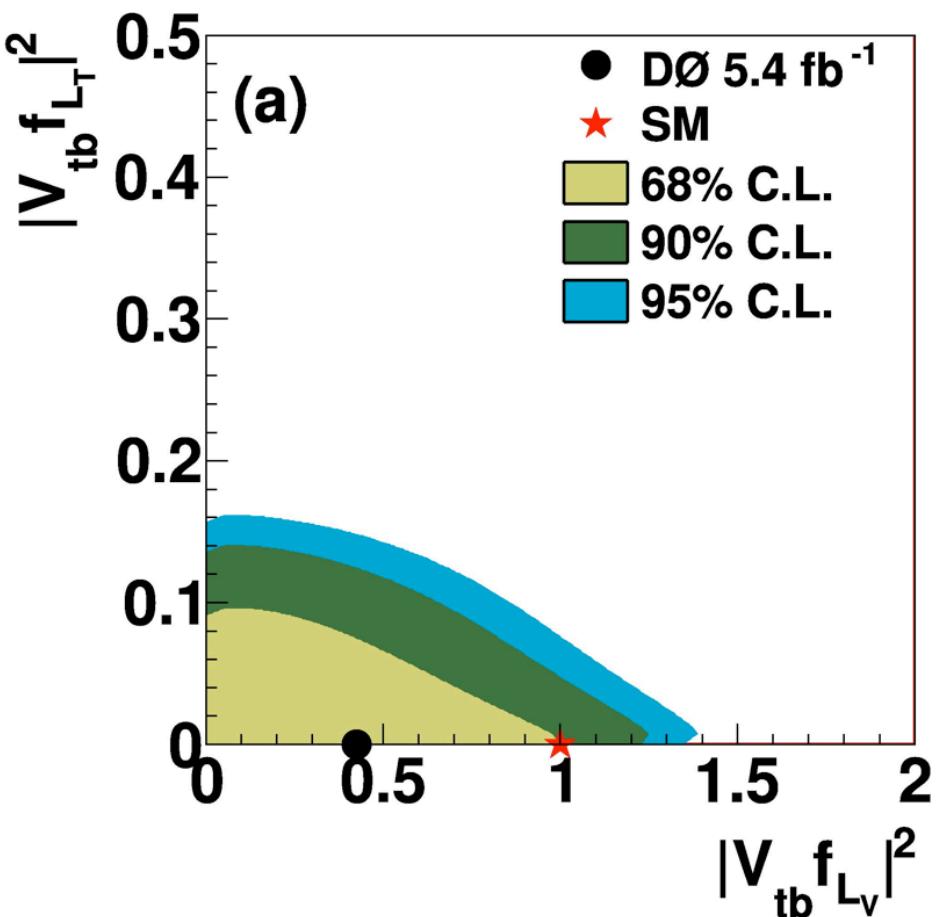


t-channel:



Phys. Lett. B 708, 21 (2012)

Victor Bazterra, 10 February

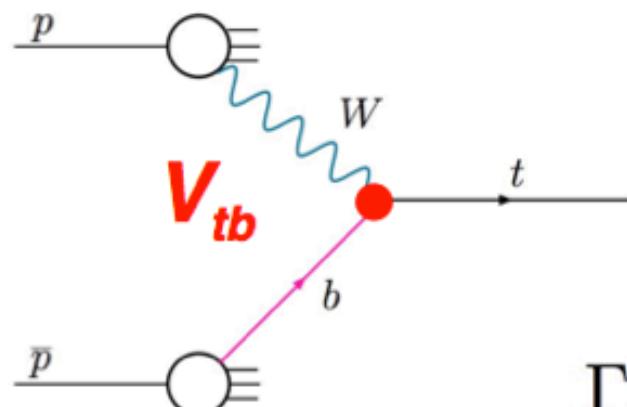


Improved Top Decay Width

t-channel cross section:

$$\sigma(\text{t-channel}) = 2.14 \pm 0.18 \text{ pb}$$

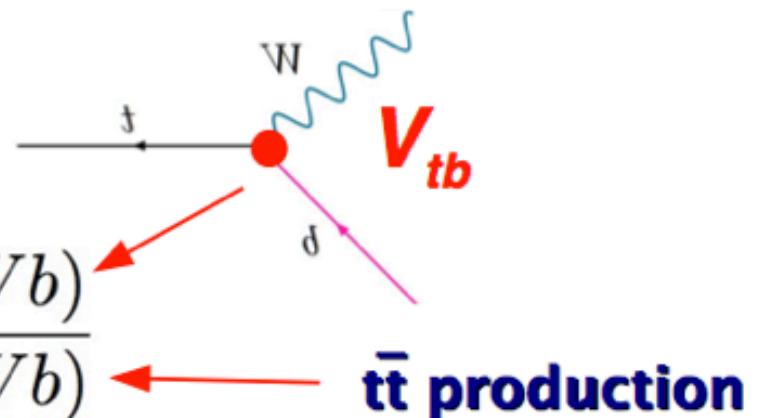
NLO, $m_t = 170 \text{ GeV}$



partial decay width:

$$\Gamma(t \rightarrow Wb) = 1.26 \text{ GeV}$$

NLO, $m_t = 170 \text{ GeV}$



$$\Gamma_t = \frac{\Gamma(t \rightarrow Wb)}{\mathcal{B}(t \rightarrow Wb)}$$

tt̄ production

assume that coupling in top production and decay is the same

arXiv:1201.4156 [hep-ex]

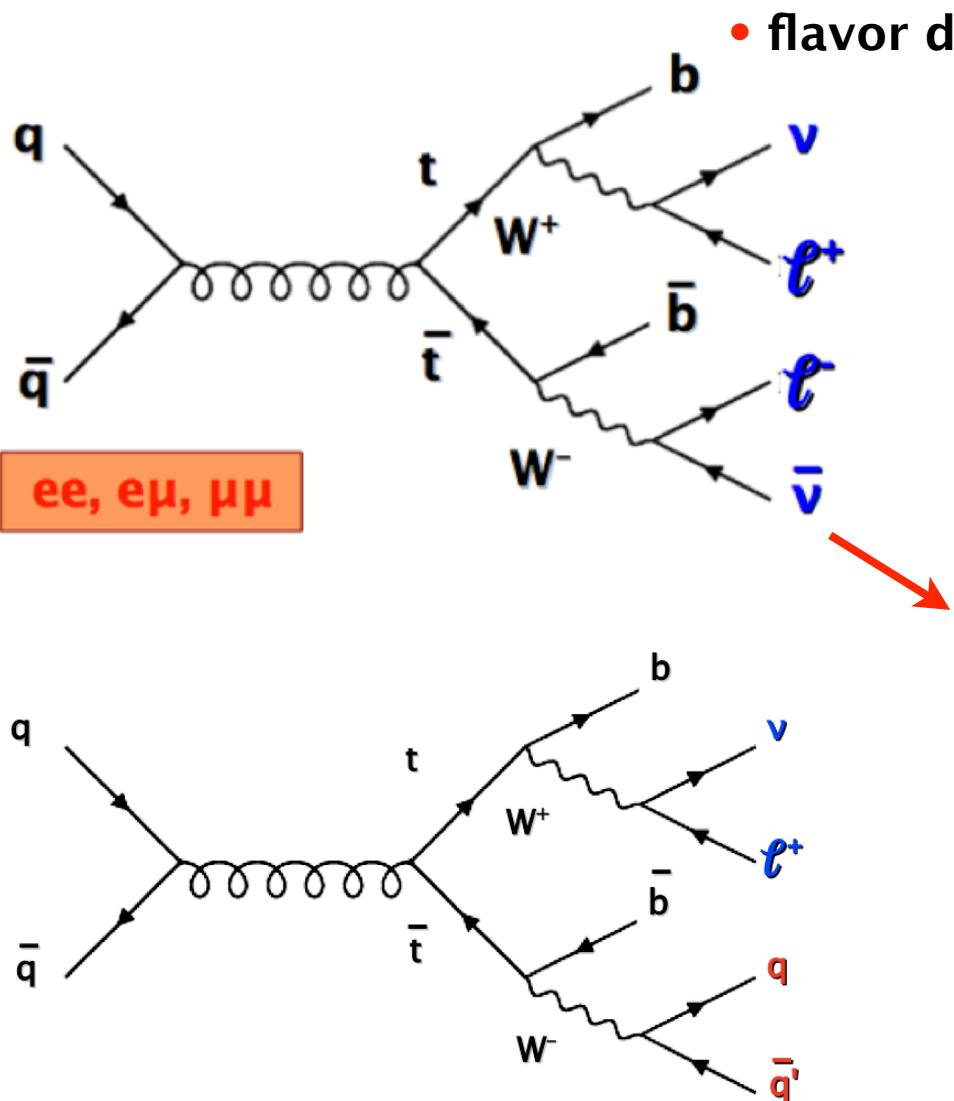
$$\Gamma_t = 2.00^{+0.47}_{-0.43} \text{ GeV}$$

$$\tau_t = (3.29^{+0.90}_{-0.63}) \times 10^{-25} \text{ s}$$

Victor Bazterra, 10 February

⇒ most precise determination

Top Quark Mass



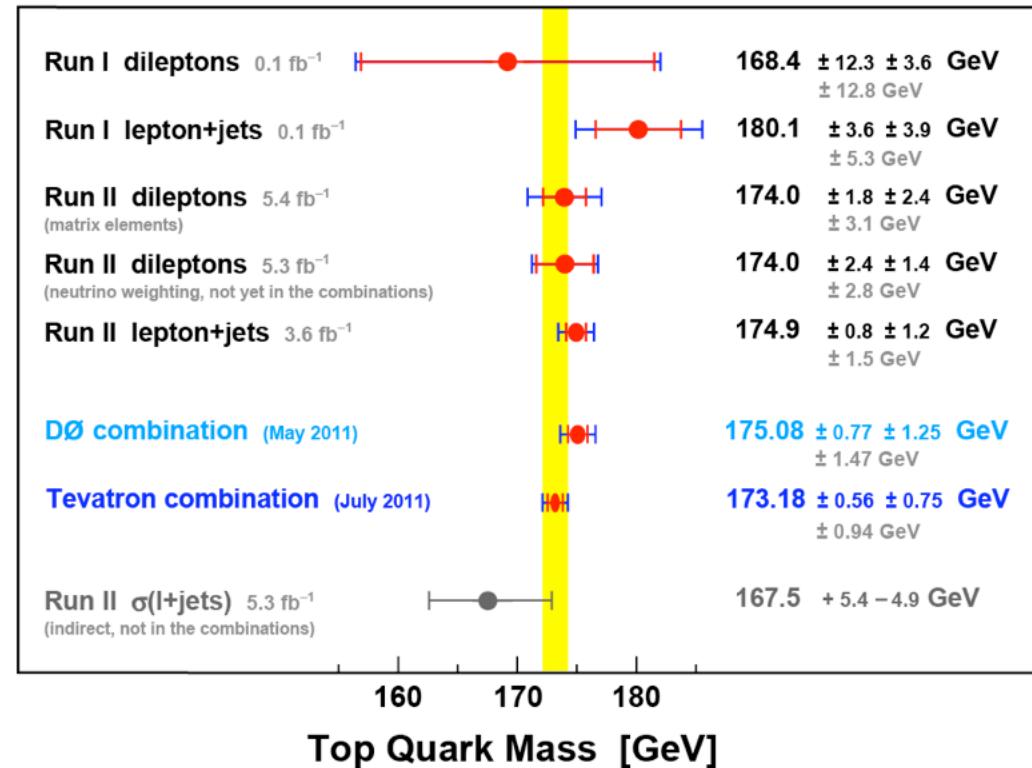
- flavor dependence of jet energy scale

systematics smaller by $\sim O(1 \text{ GeV})$

$$m_t = 174.0 \pm 2.4(\text{stat}) \pm 1.4(\text{syst}) \text{ GeV}$$

DØ

January 2012



- calibration of jet energy scale

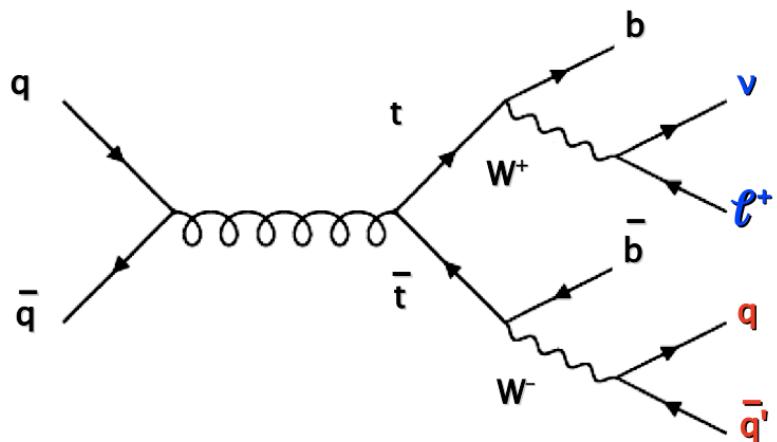
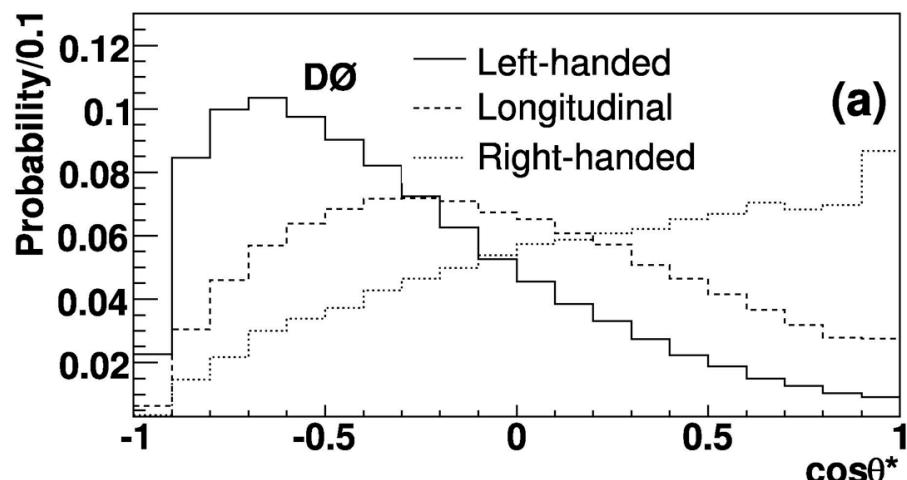
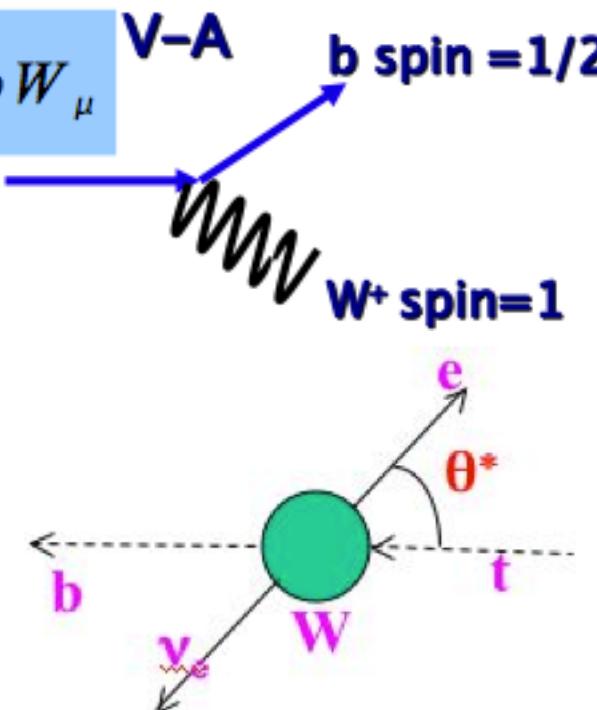
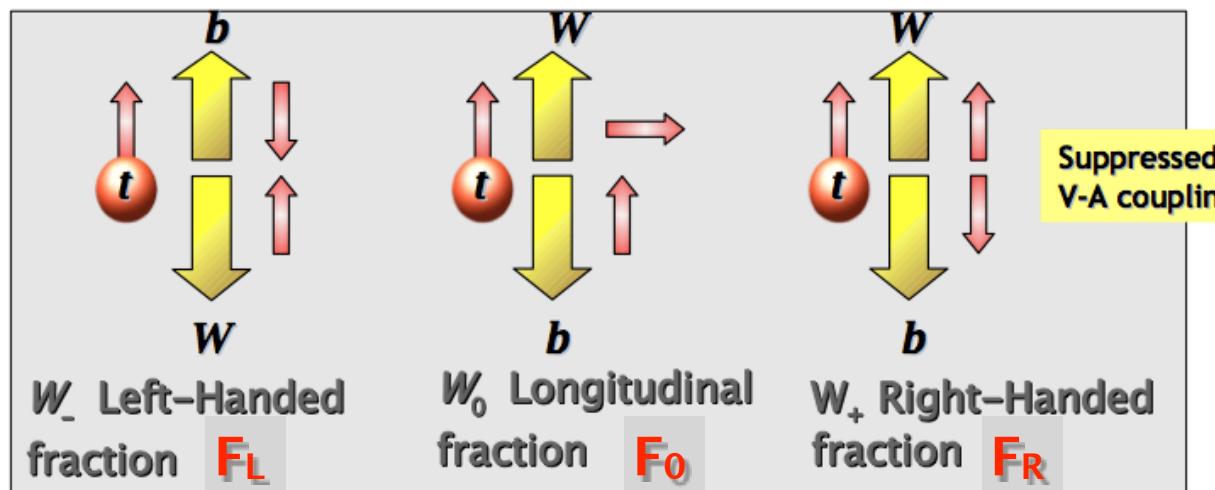
⇒ improve systematic uncertainties

W Boson Helicity Fractions

Phys. Rev. D83, 032009 (2011)

$$\frac{-ig}{2\sqrt{2}} \bar{t} \gamma^\mu (1 - \gamma^5) V_{tb} b W_\mu$$

V-A
t spin = 1/2

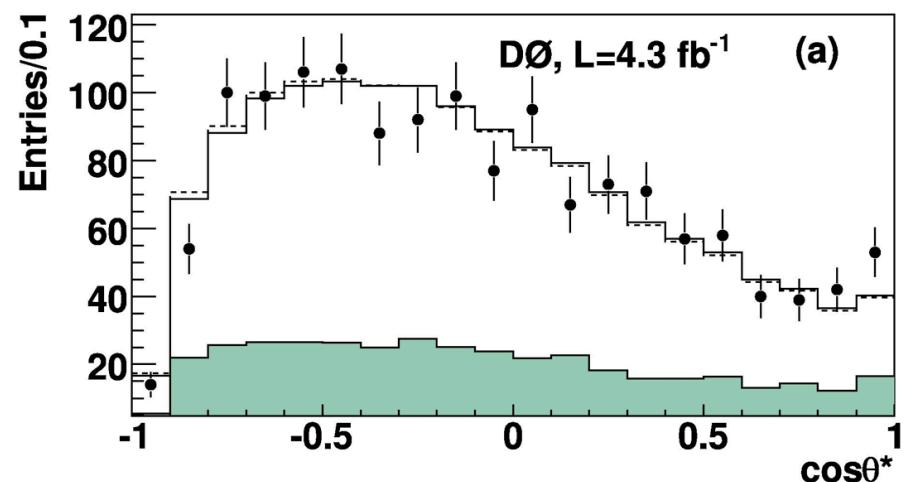
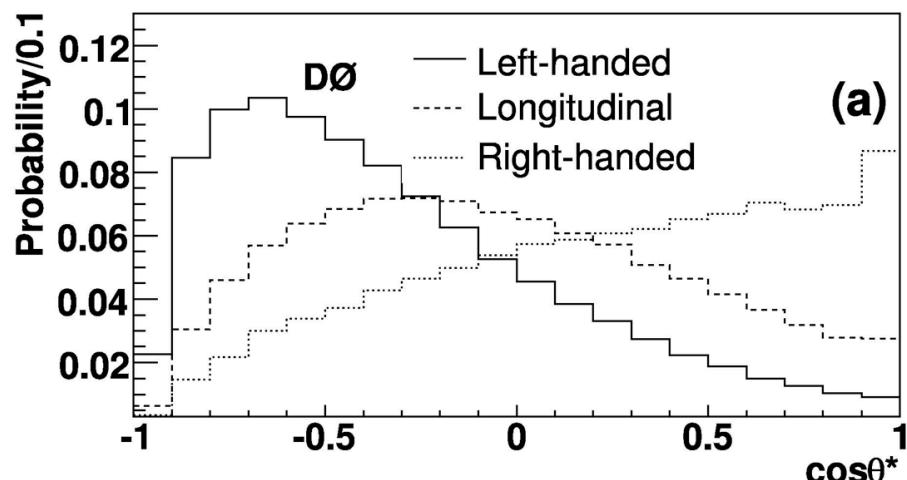
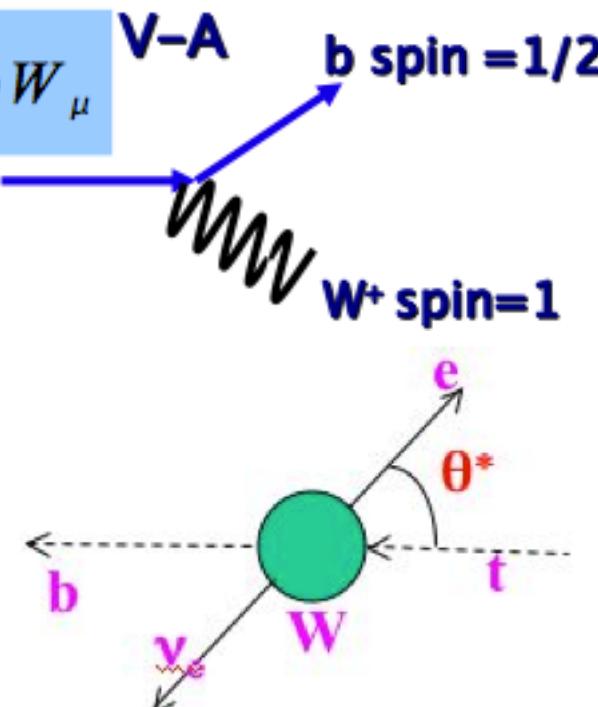
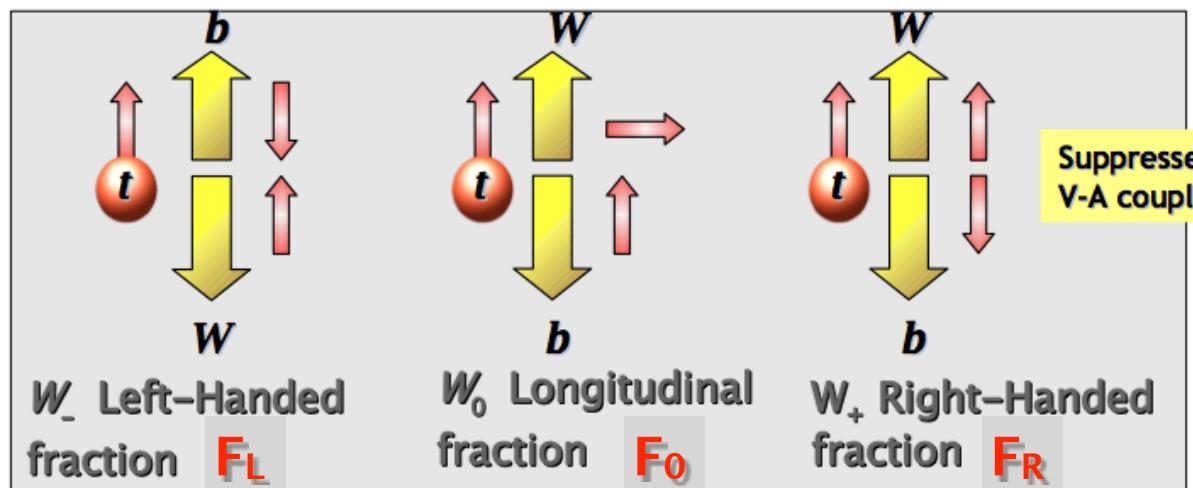


W Boson Helicity Fractions

Phys. Rev. D83, 032009 (2011)

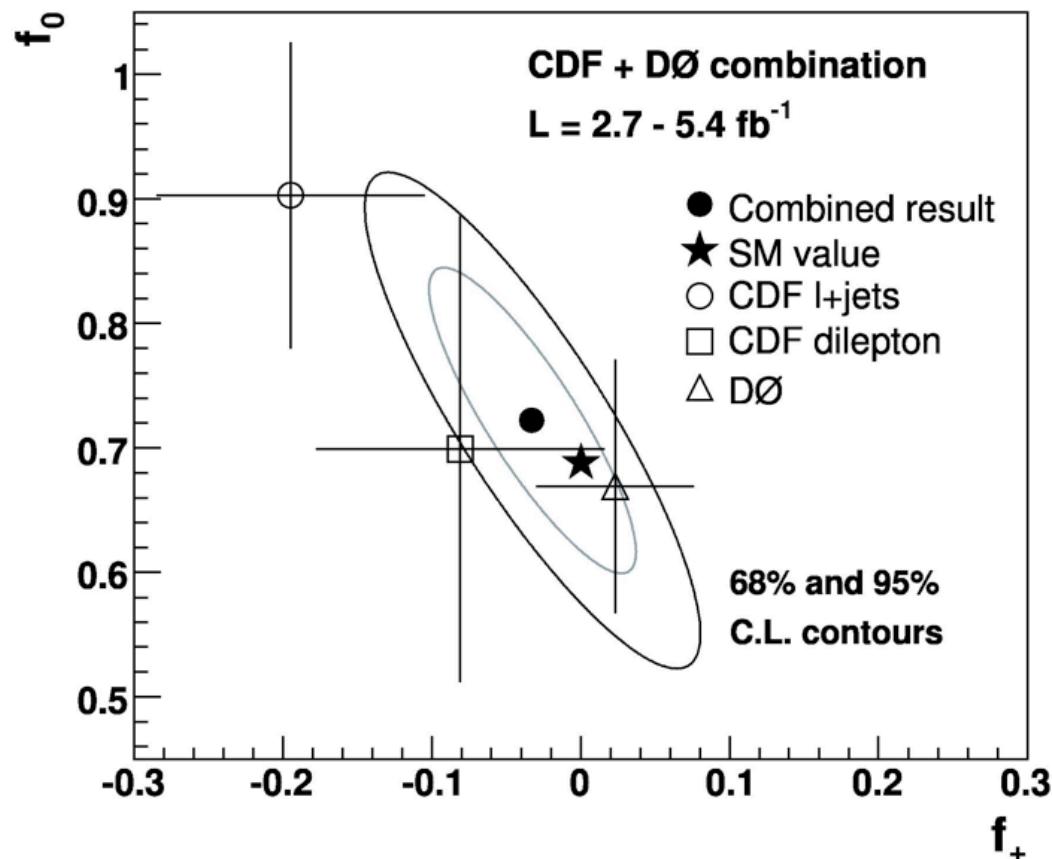
$$\frac{-ig}{2\sqrt{2}} \bar{t} \gamma^\mu (1 - \gamma^5) V_{tb} b W_\mu$$

V-A
t spin = 1/2



W Boson Helicity Fractions

arXiv:1202.5272 [hep-ex]



$$f_0 = 0.722 \pm 0.081$$

$[\pm 0.062 \text{ (stat.)} \pm 0.052 \text{ (syst.)}]$,

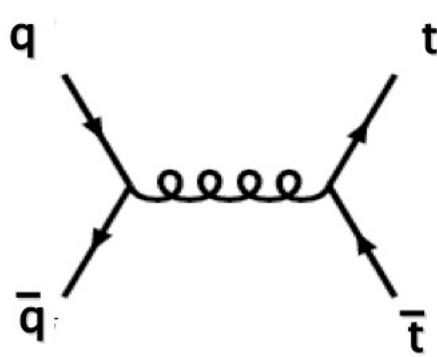
$$f_+ = -0.033 \pm 0.046$$

$[\pm 0.034 \text{ (stat.)} \pm 0.031 \text{ (syst.)}]$

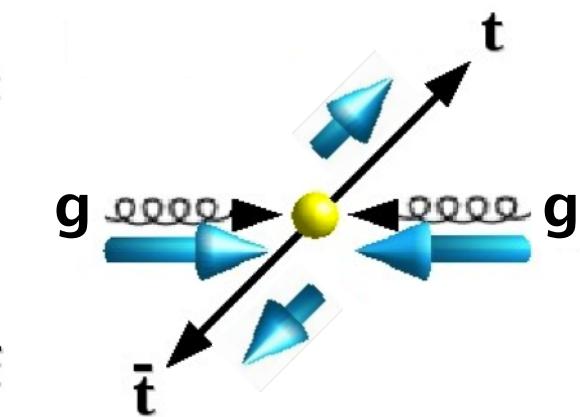
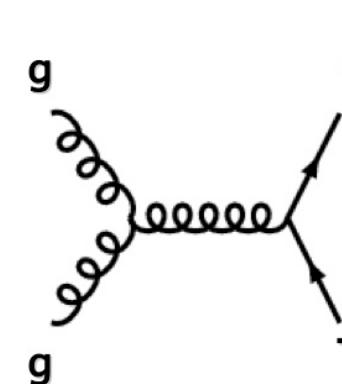
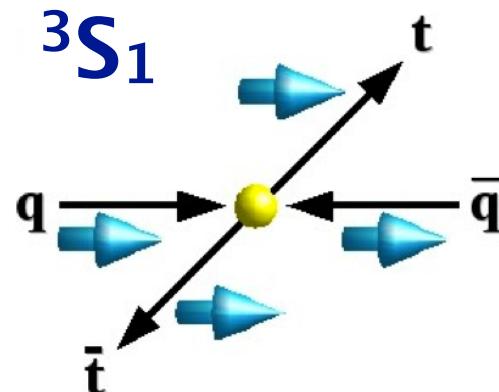
- ⇒ first published Tevatron combination in top quark physics
- ⇒ most precise measurement to date

Spin correlation strength

$$C = \frac{N_{\uparrow\uparrow} + N_{\downarrow\downarrow} - N_{\uparrow\downarrow} - N_{\downarrow\uparrow}}{N_{\uparrow\uparrow} + N_{\downarrow\downarrow} + N_{\uparrow\downarrow} + N_{\downarrow\uparrow}}$$



Tevatron



LHC

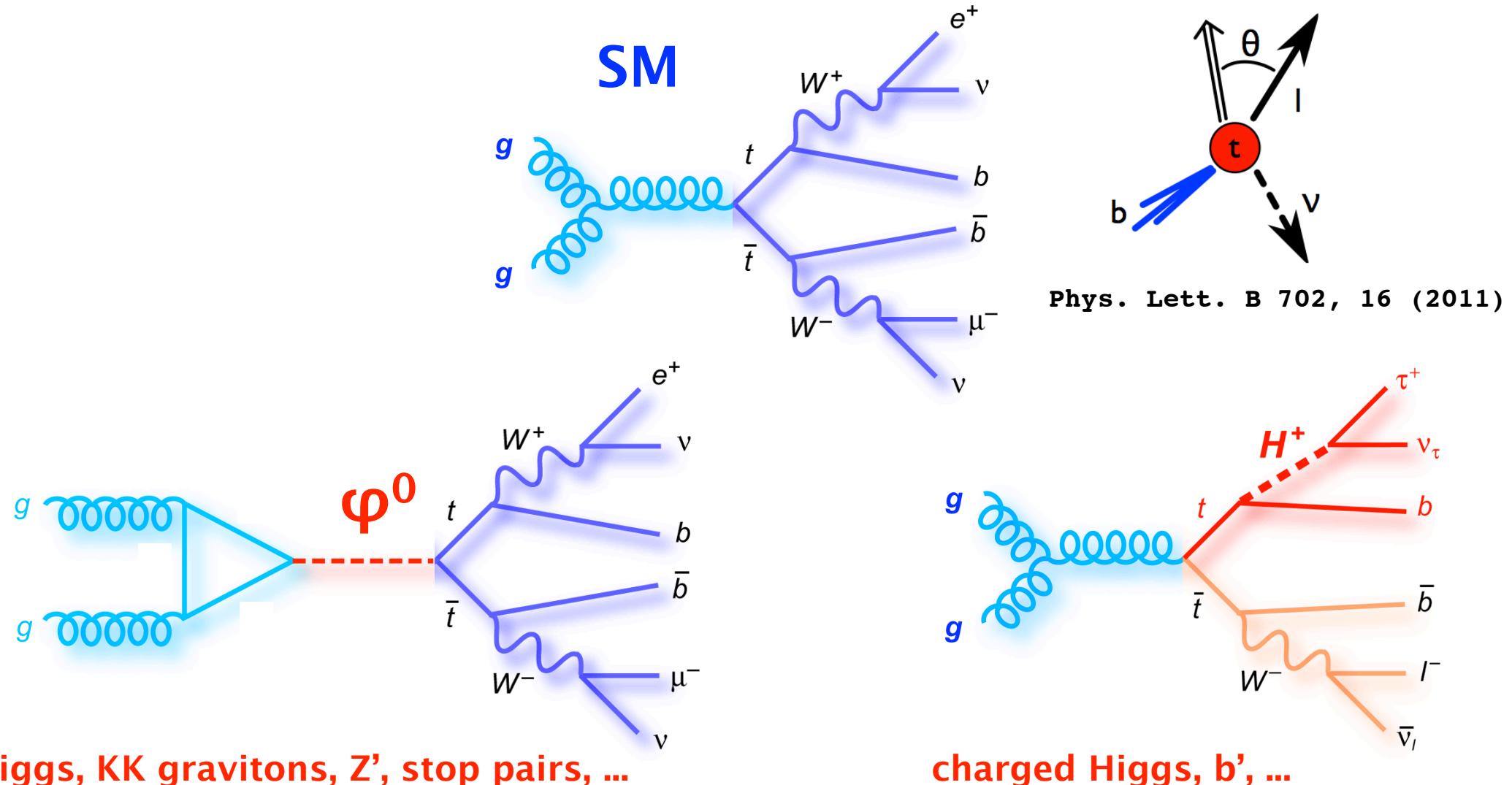
- dominated by $q\bar{q}$ annihilation
 - $t\bar{t}$ pairs close to the threshold
 - beam axis as spin quantisation axis
- NLO QCD: $C = 0.78$
- Bernreuther, Brandenburg, Si, Uwer, Nucl. Phys. B690, 81 (2004)
- optimised “off-diagonal” basis

- dominated by gg fusion
 - $t\bar{t}$ pairs far off the threshold
 - helicity basis as spin quantisation axis
- NLO QCD: $C = 0.32$
- maximal basis

complementary between Tevatron and LHC

New physics impact on spin correlations

- important test of SM and sensitive search for physics beyond
- analyse the whole chain of top pair production and top decay



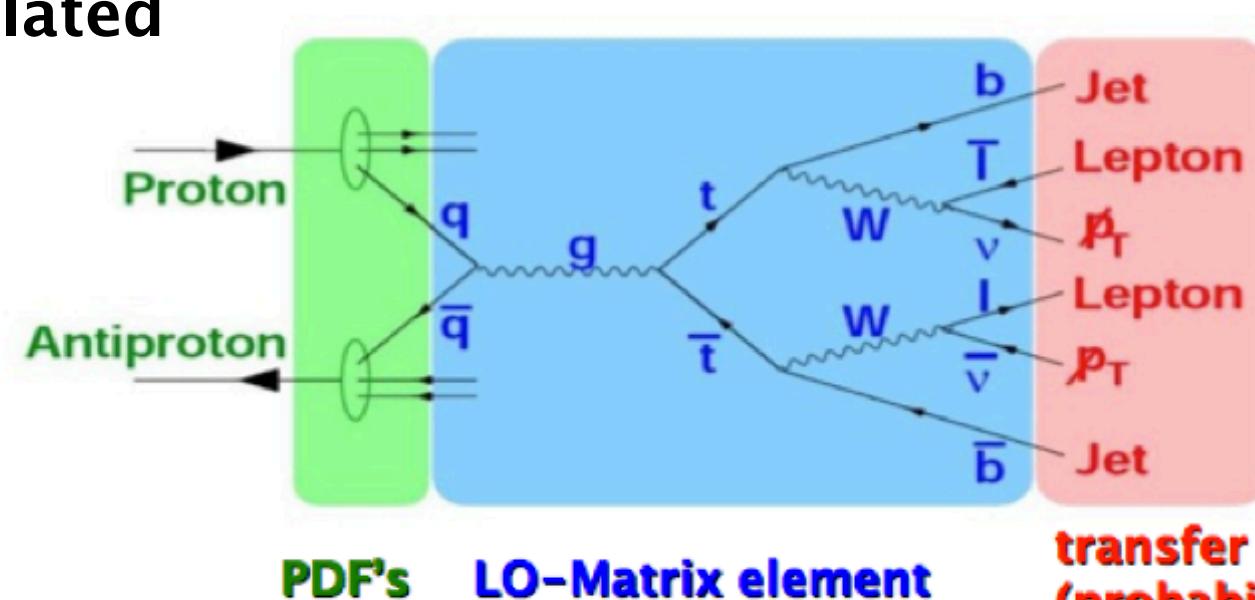
Higgs, KK gravitons, Z', stop pairs, ...

charged Higgs, b', ...

Matrix Element Method

**H=correlated
or
H=uncorrelated
spins**

$$P_{\text{sgn}}(x; m_t, H) = \frac{1}{\sigma_{\text{obs}}(m_t)} \int f_{\text{PDF}}(\epsilon_1) f_{\text{PDF}}(\epsilon_2) d\epsilon_1 d\epsilon_2 \cdot \frac{(2\pi)^4 |\mathcal{M}(y, m_t, H)|^2}{\epsilon_1 \epsilon_2 s} W(x, y) d\Phi_6$$

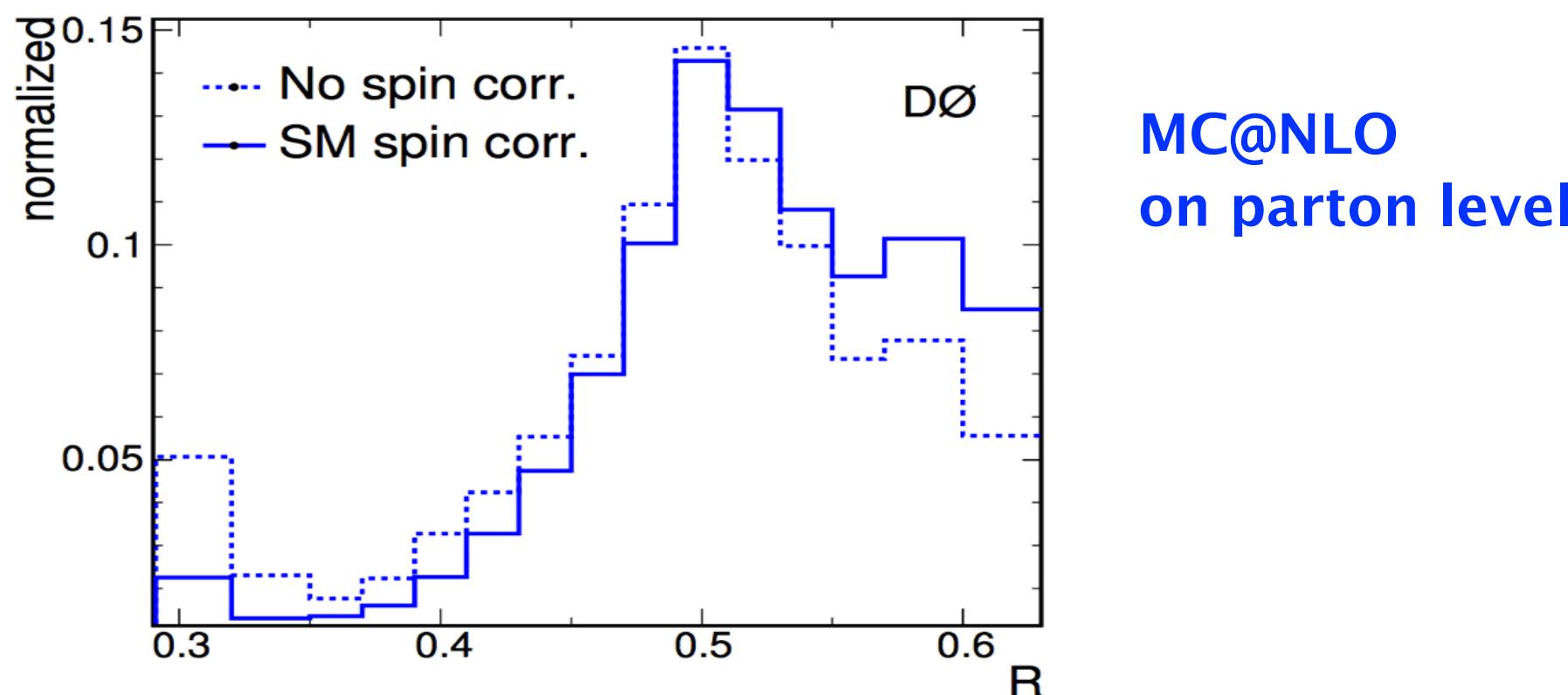


Measurement of Spin Correlation

MEs: per event \leftrightarrow spin correlation: ensemble of events

discriminant

$$R = \frac{P_{\text{sgn}}(H = c)}{P_{\text{sgn}}(H = u) + P_{\text{sgn}}(H = c)}$$

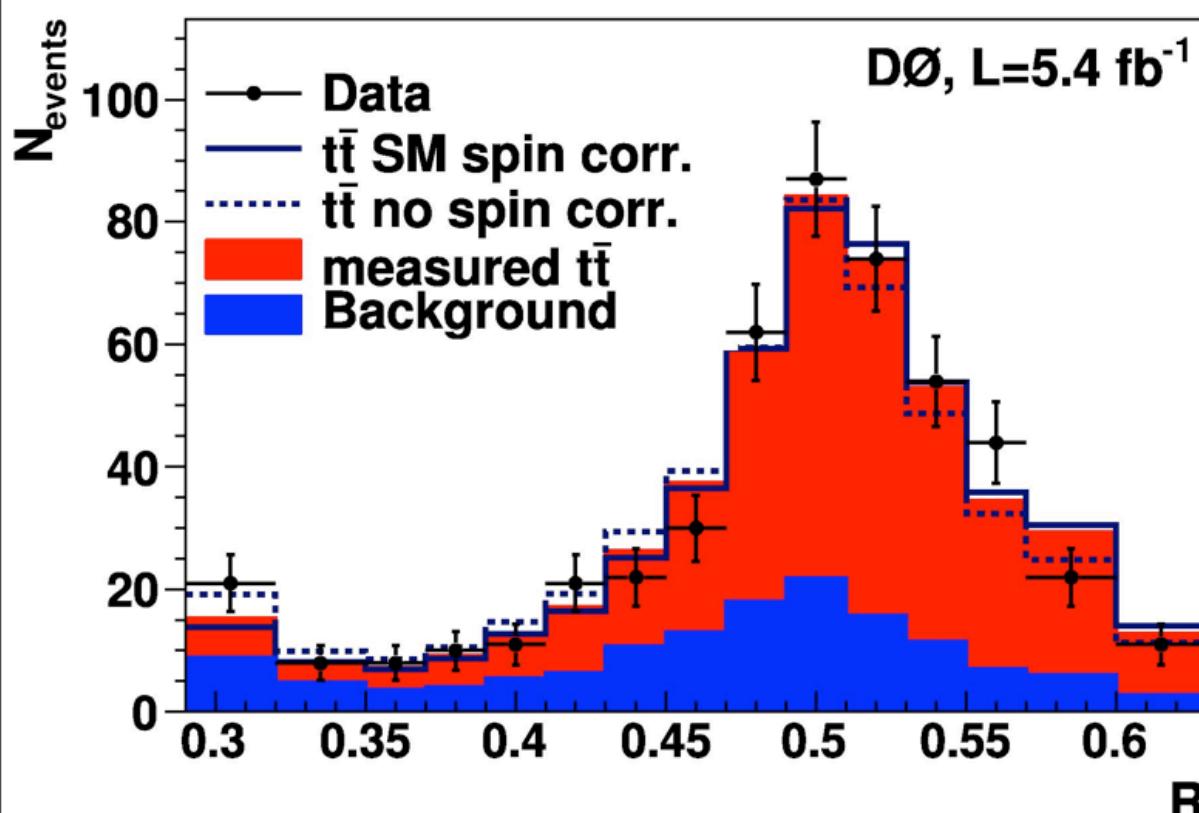


Measurement of Spin Correlation

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dilepton

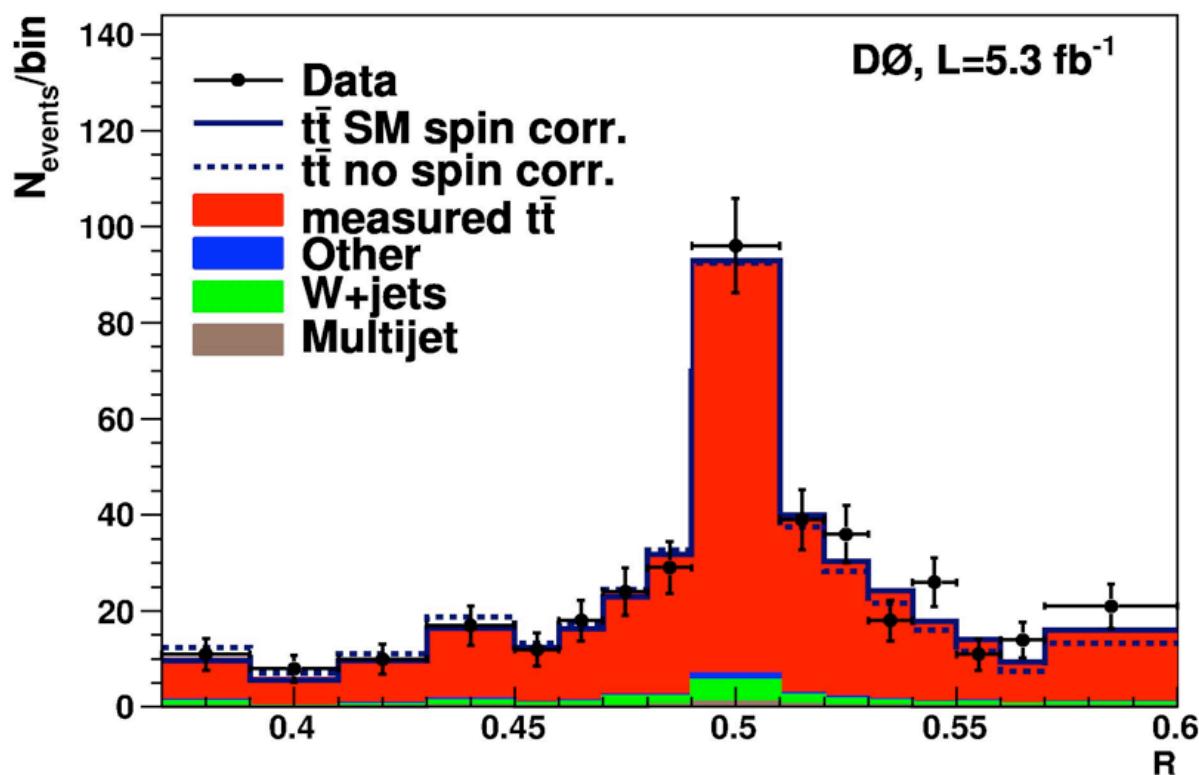
Phys. Rev. Lett. 107, 032001 (2011)

Measurement of Spin Correlation

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$$R = \frac{P_{\text{sgn}}(H = c)}{P_{\text{sgn}}(H = u) + P_{\text{sgn}}(H = c)}$$



$|+jets$

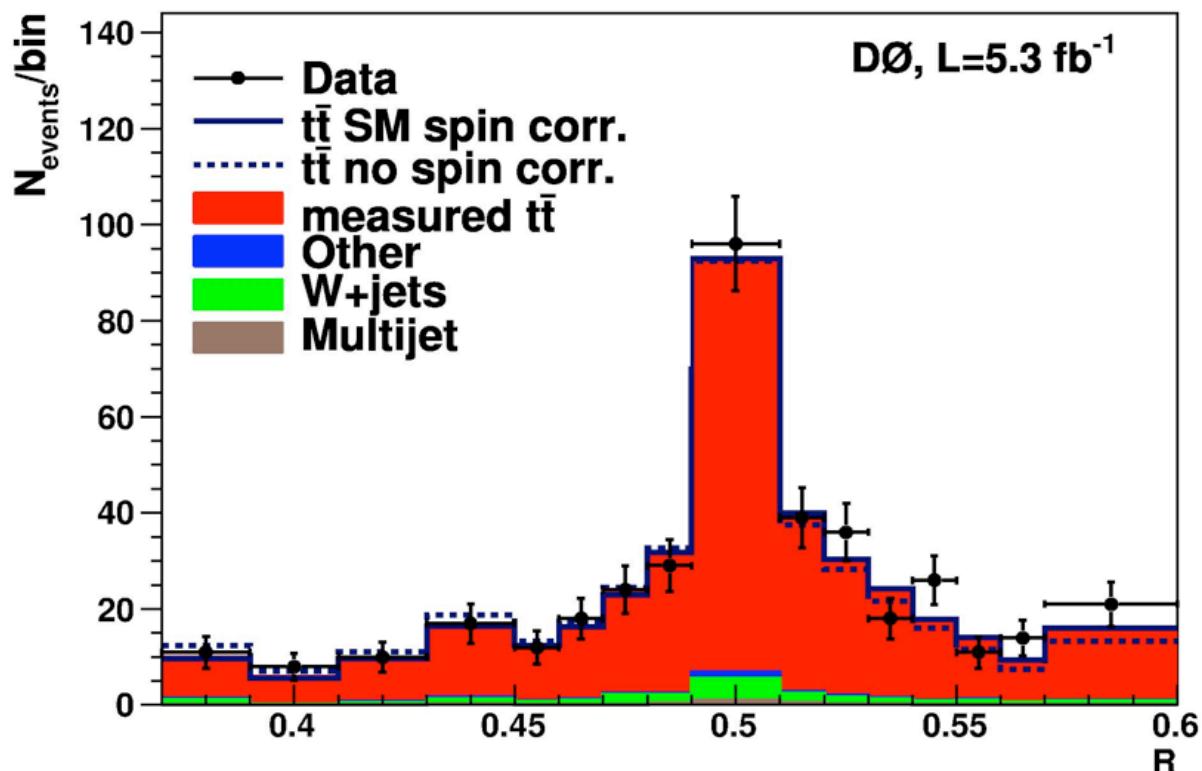
Phys. Rev. Lett. 108, 032004 (2012)

Measurement of Spin Correlation

MEs: per event \leftrightarrow spin correlation: ensemble of events

discriminant

$$R = \frac{P_{\text{sgn}}(H = c)}{P_{\text{sgn}}(H = u) + P_{\text{sgn}}(H = c)}$$



→ first evidence for spin correlation with 3.1σ

combination:
dilepton & l+jets

Phys. Rev. Lett. 107, 032001 (2011)

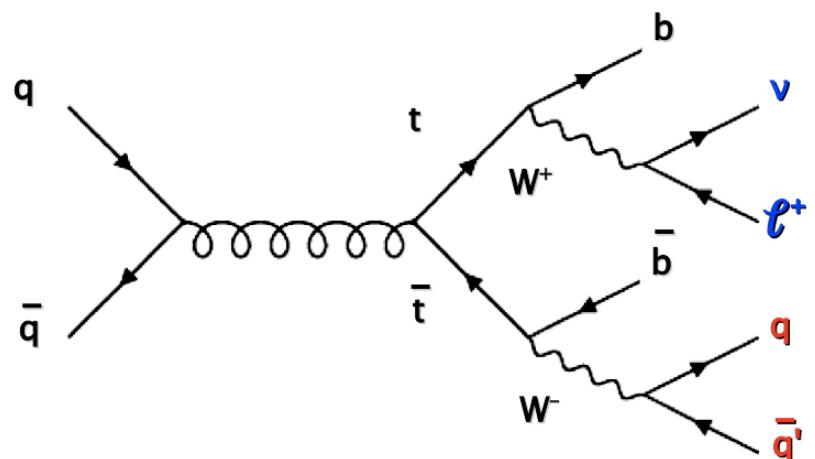
Phys. Rev. Lett. 108, 032004 (2012)

correlation strength:

$C = 0.66 \pm 0.23$ (stat+syst)

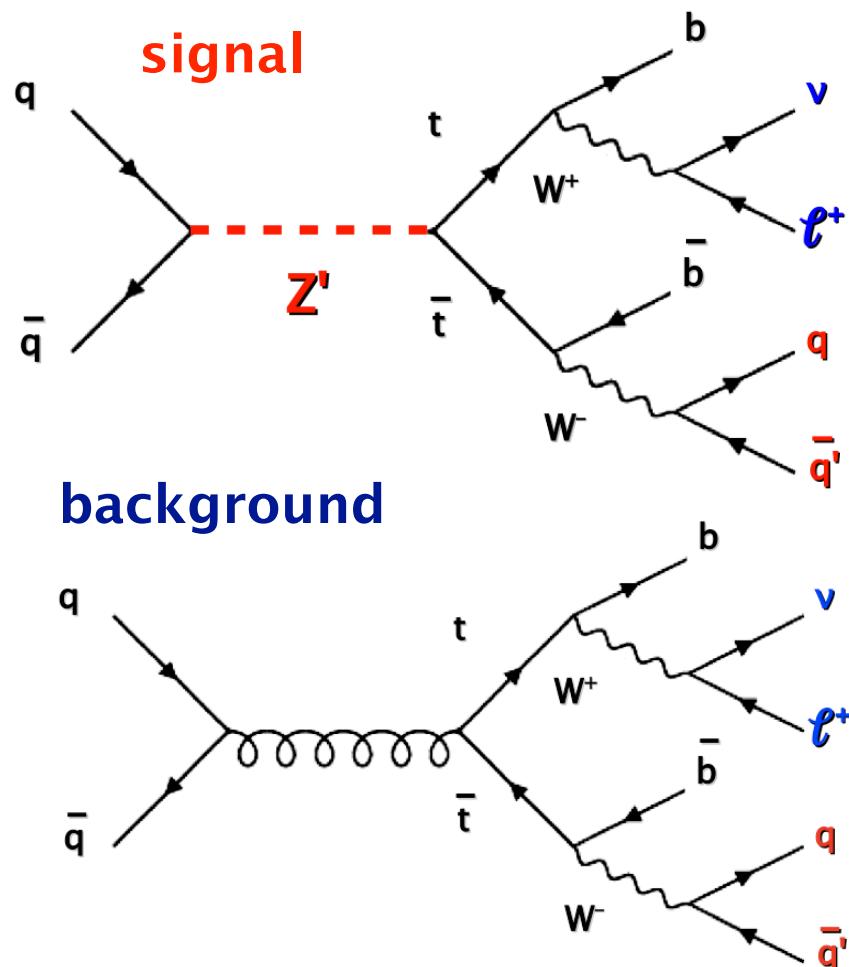
NLO QCD: $C = 0.777^{+0.027}_{-0.042}$

Search for a Narrow $t\bar{t}$ Resonance



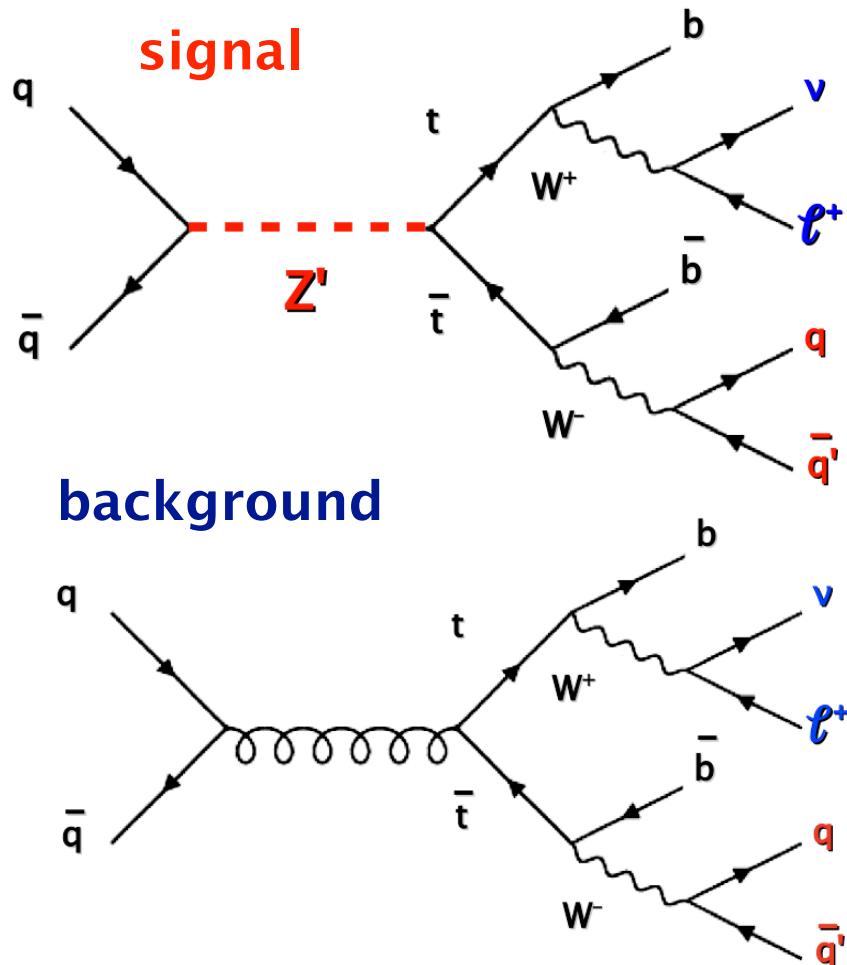
Search for a Narrow $t\bar{t}$ Resonance

- some models predict $t\bar{t}$ boundstate:
topcolor assisted technicolor predicts
generation coupling
- leptophobic Z'

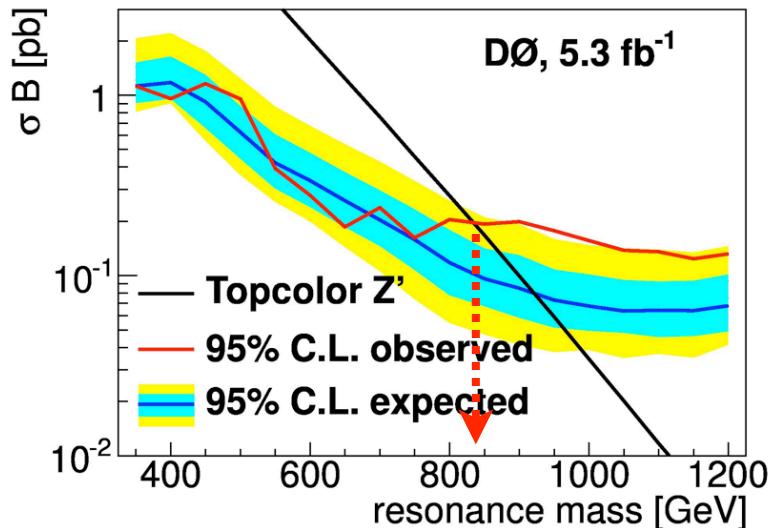
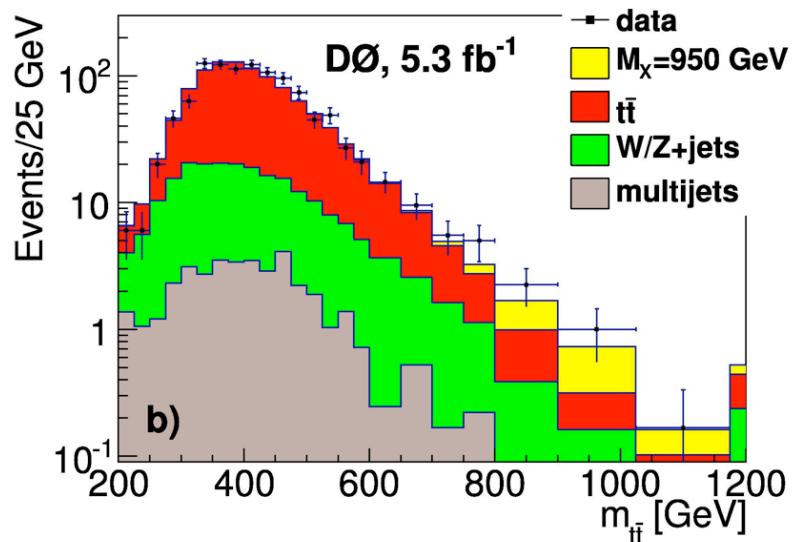


Search for a Narrow $t\bar{t}$ Resonance

- some models predict $t\bar{t}$ boundstate: topcolor assisted technicolor predicts generation coupling
- leptophobic Z'



- search for bumps in:



arXiv:1111.1271 [hep-ex]

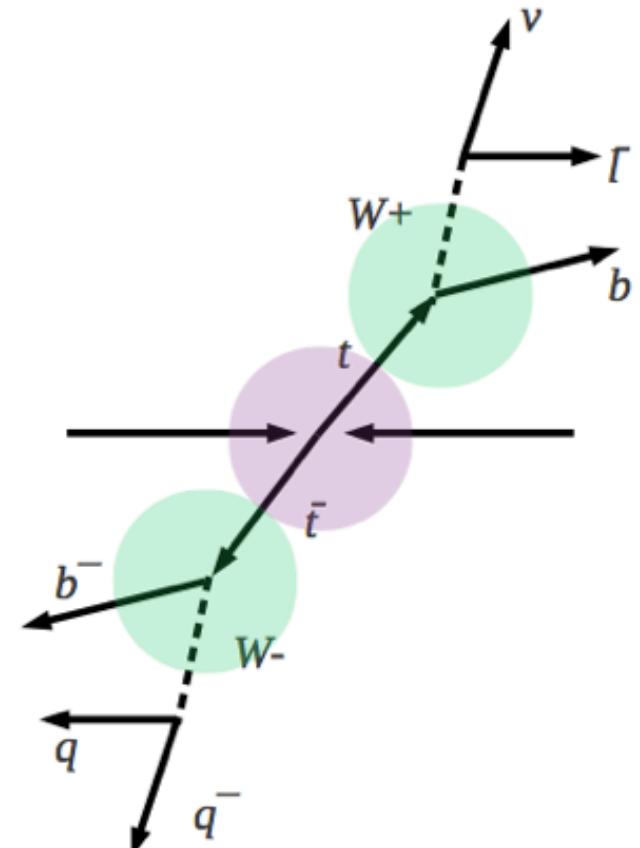
$m_{Z'} \leq 835 \text{ GeV}$

Search for Lorentz Invariance Violation

- General Lorentz-violating terms added to SM Lagrangian
 - Effective field theory treatment for LV
 - Not constrained to be the same for all particle species

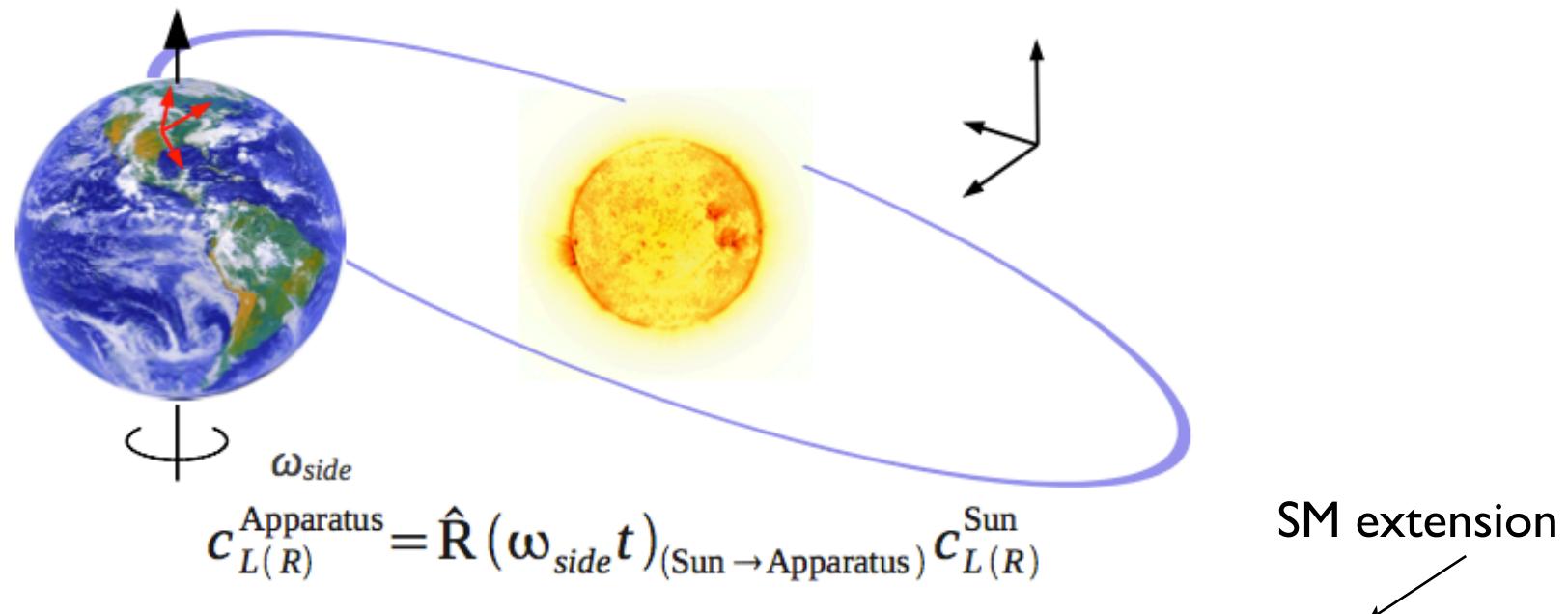
$$|M|^2 = \overbrace{P F \bar{F}}^{\text{Standard Model}} + (c_R + c_L)_{\mu\nu} \underbrace{(\delta P_p + \delta P_v)^{\mu\nu} F \bar{F}}_{\text{Production Corrections}} + (c_L)_{\mu\nu} \underbrace{(P(\delta F)^{\mu\nu} \bar{F} + P F (\delta \bar{F})^{\mu\nu})}_{\text{Decay Corrections}}$$

- c_R and c_L are symmetric, traceless matrices containing coefficients which parametrize the strength of Lorentz violation in the top quark sector
- Set limits on elements of c_R and c_L , as well as linear combinations $c = c_L + c_R$ and $d = c_L - c_R$.
- Top sector only accessible to high-energy particle colliders
 - Tight limits already set on LV other particle sectors



Search for Lorentz Invariance Violation

- GOAL: Estimate components of c_R and c_L matrices



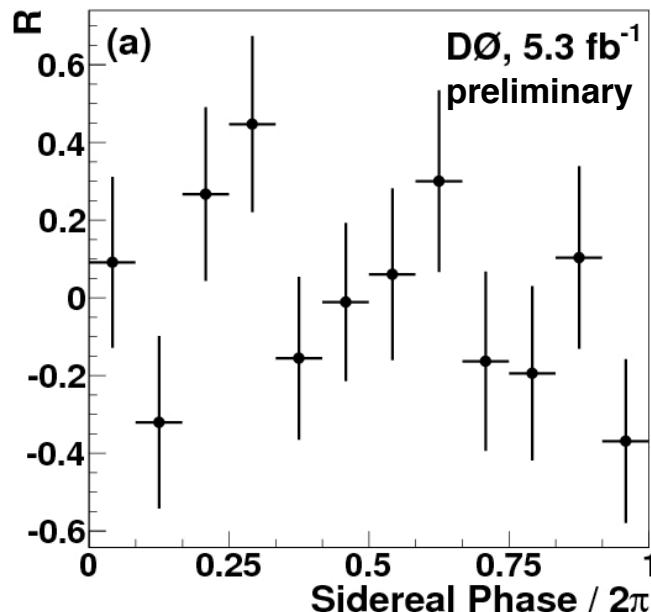
- D-Zero events projected onto different components of SME matrices c_R and c_L
 - Varies with sidereal frequency as detector rotates with Earth
 - Unique signature!
 - Time-dependent event rate.

Search for Lorentz Invariance Violation

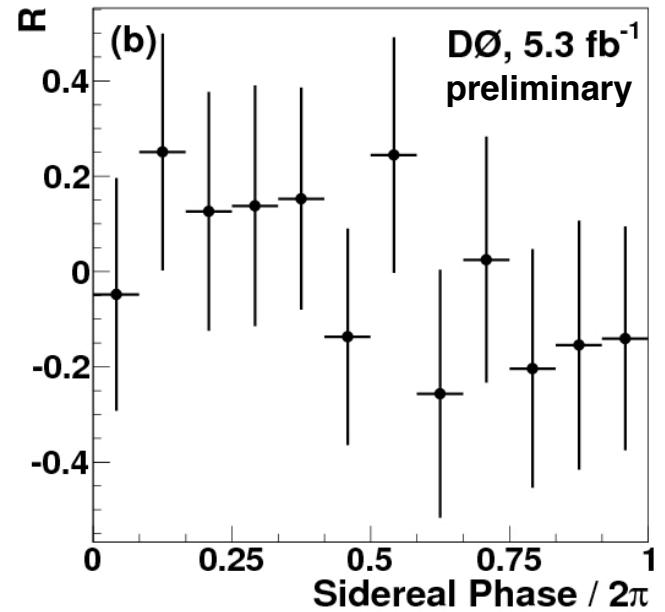
$$N_i \approx N_{\text{tot}} \frac{\mathcal{L}_i}{\mathcal{L}_{\text{int}}} [1 + f_S f_{SME}(\phi_i)]$$

- › \mathcal{L}_i is the integrated luminosity over appropriate bin of sidereal phase ϕ_i
- › f_S is the fraction of signal ($t\bar{t}$) events

$$R_i \equiv \frac{1}{f_S} \left(\frac{N_i/N_{S+B}}{\mathcal{L}_i/\mathcal{L}_{\text{int}}} - 1 \right)$$



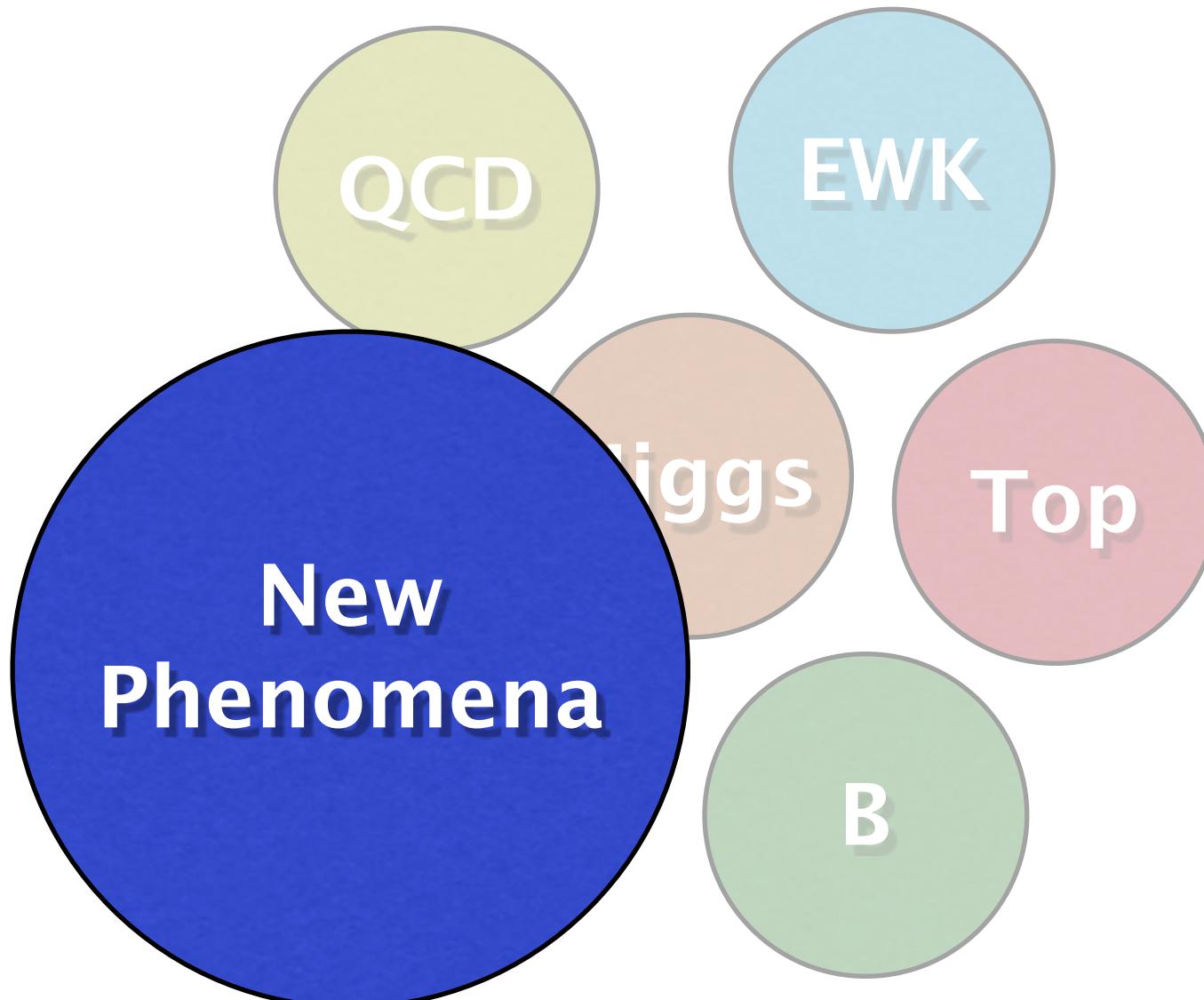
(a) $e+ > 3$ -jets $t\bar{t}$ candidates



(b) $\mu+ > 3$ -jets $t\bar{t}$ candidates

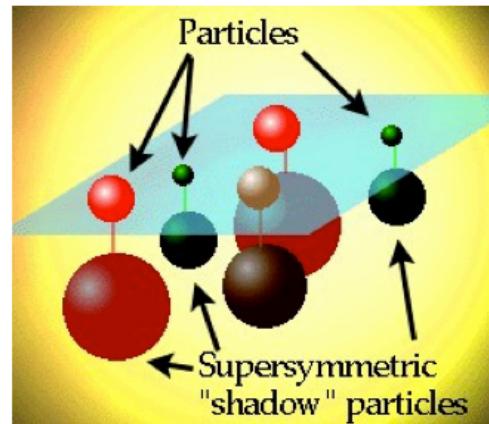
- no indication of time dependence of $t\bar{t}$ cross section
- first constraints on LIV in free quark sector $(c_L)_{XX}, (c_L)_{XY}, \dots, (c_R)_{XX}, \dots$

DØ Physics Results for Winter 2012

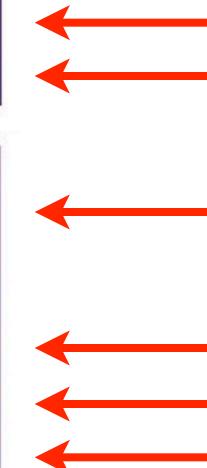


Beyond the Standard Model

Supersymmetry

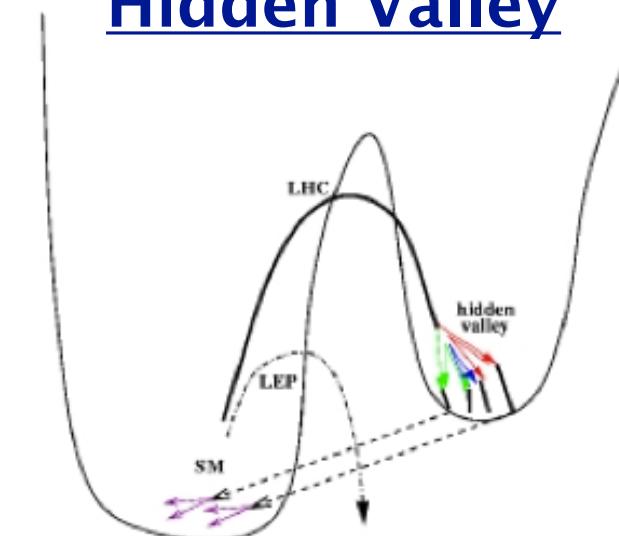
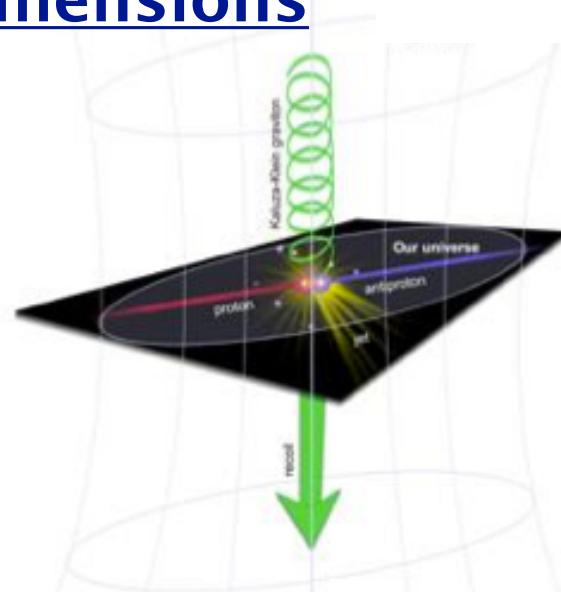


Name	Spin	Superpartner	Spin
Electron	1/2	Selectron	0
Muon	1/2	Smuon	0
Tau	1/2	Stau	0
Neutrino	1/2	Sneutrino	0
Quark	1/2	Squark	0



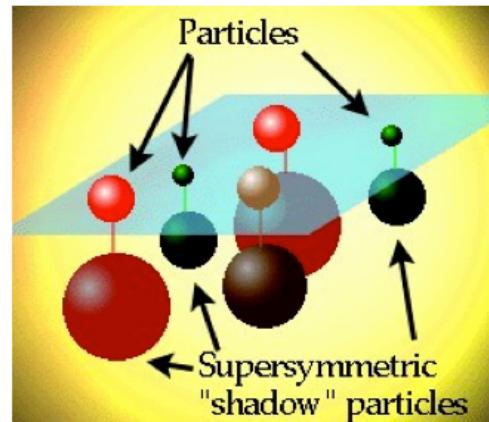
Name	Spin	Superpartner	Spin
Graviton	2	Gravitino	3/2
Photon	1	Photino	1/2
Gluon	1	Gluino	1/2
$W^{+,-}$	1	$Wino^{+,-}$	1/2
Z^0	1	Zino	1/2
Higgs	0	Higgsino	1/2

Hidden Valley

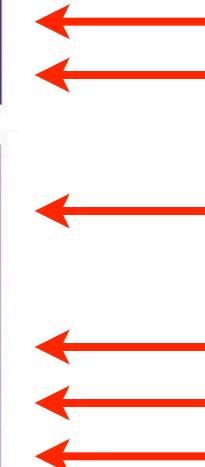


Beyond the Standard Model

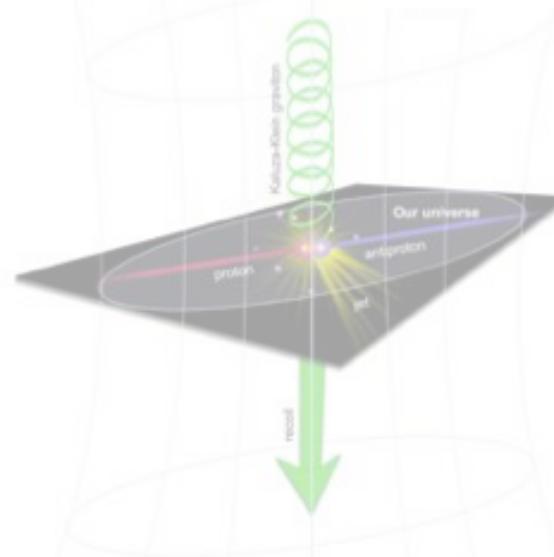
Supersymmetry



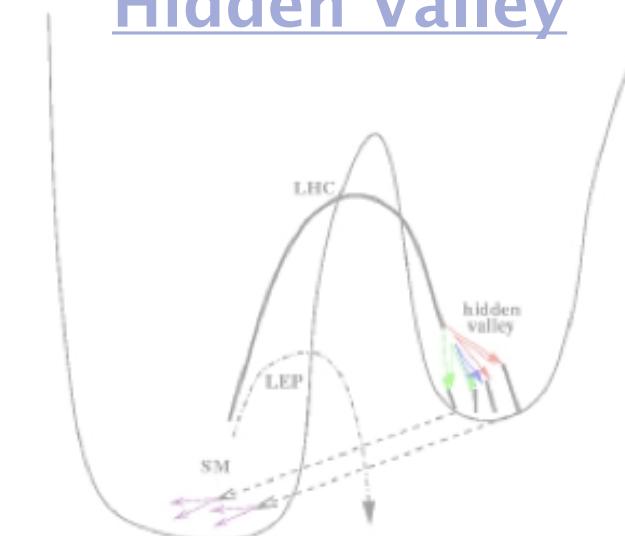
Name	Spin	Superpartner	Spin
Electron	1/2	Selectron	0
Muon	1/2	Smuon	0
Tau	1/2	Stau	0
Neutrino	1/2	Sneutrino	0
Quark	1/2	Squark	0



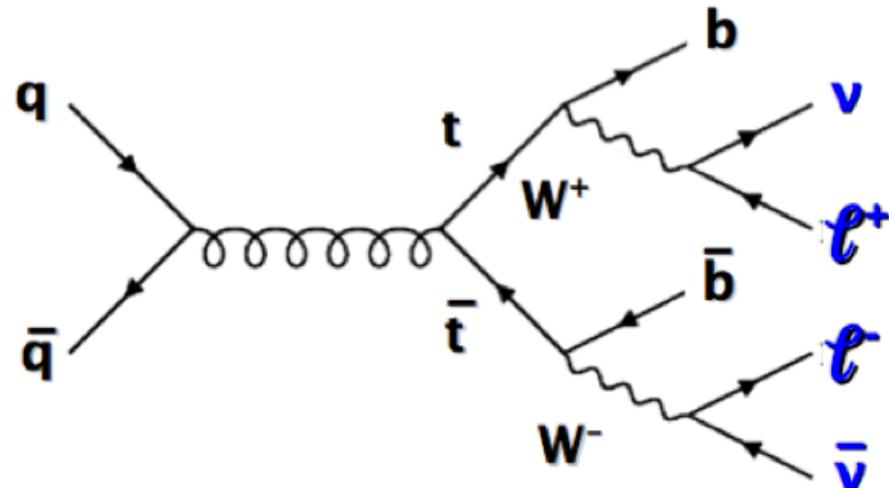
Extra dimensions



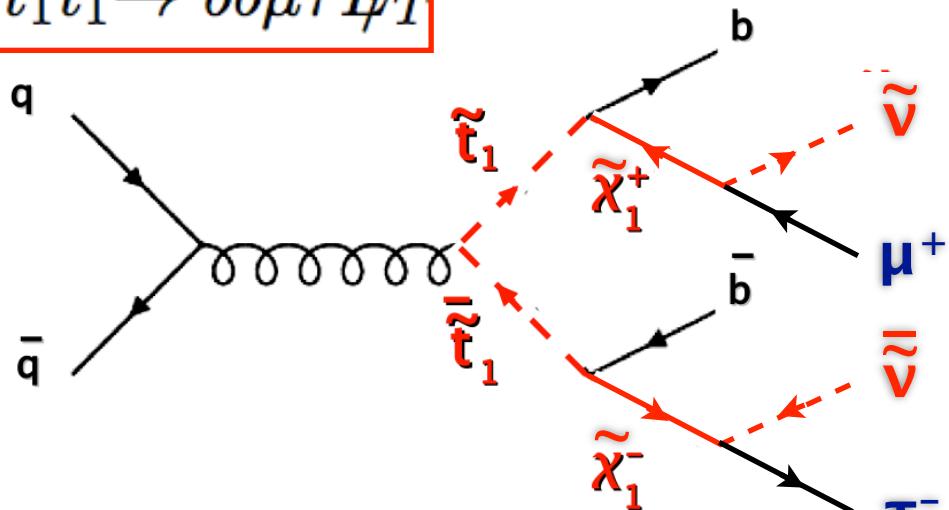
Hidden Valley



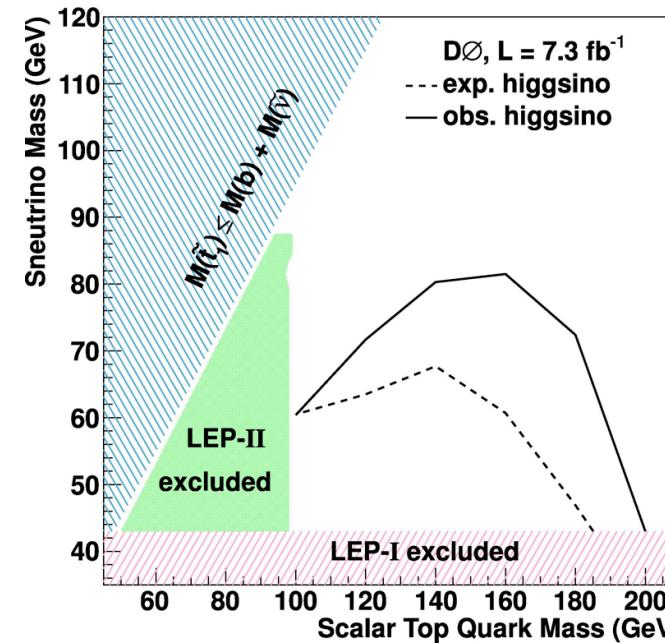
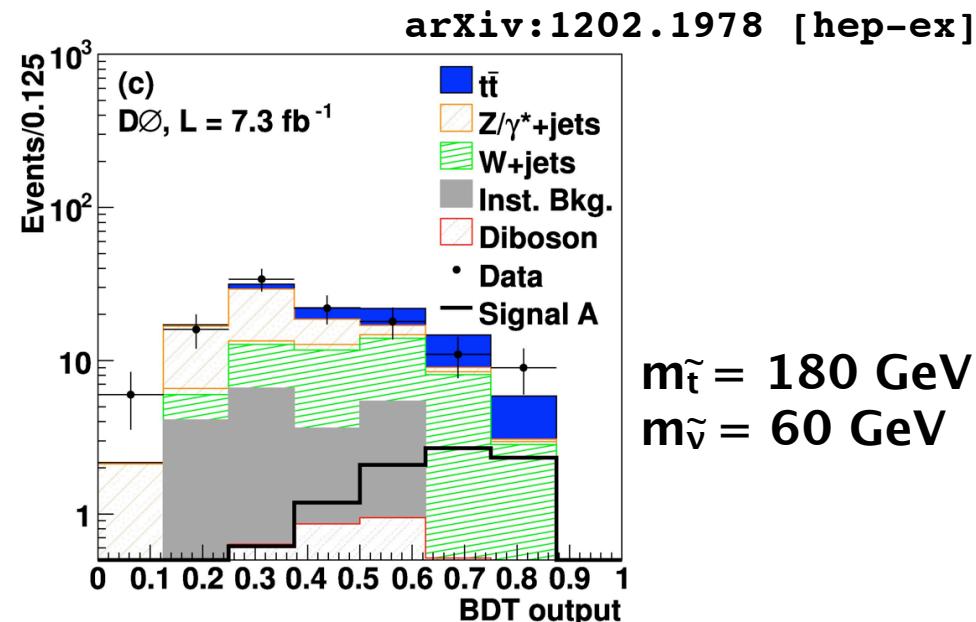
Search for Stop Pair Production



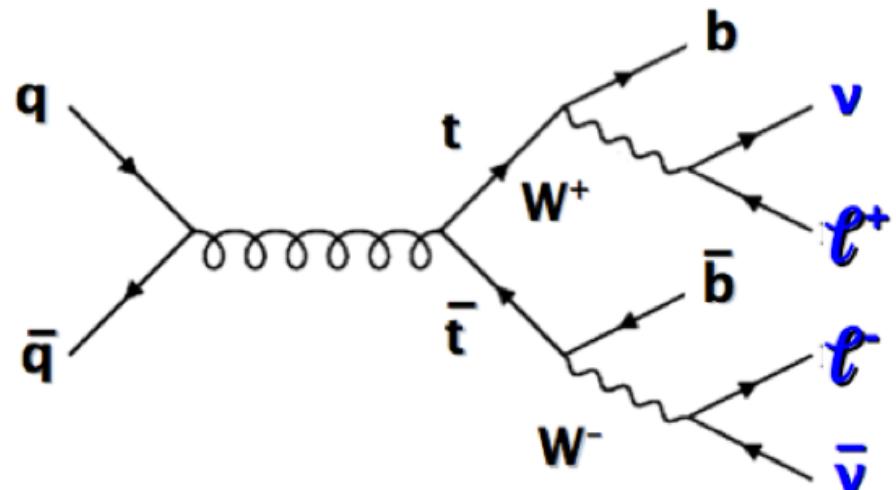
$\tilde{t}_1\tilde{t}_1 \rightarrow b\bar{b}\mu\tau E_T$



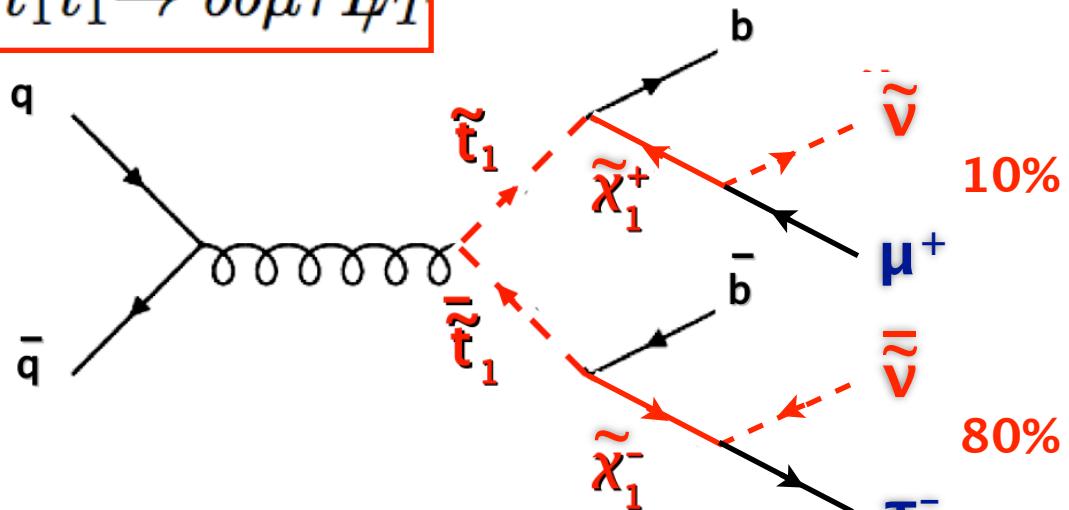
SUSY search in 3rd generation



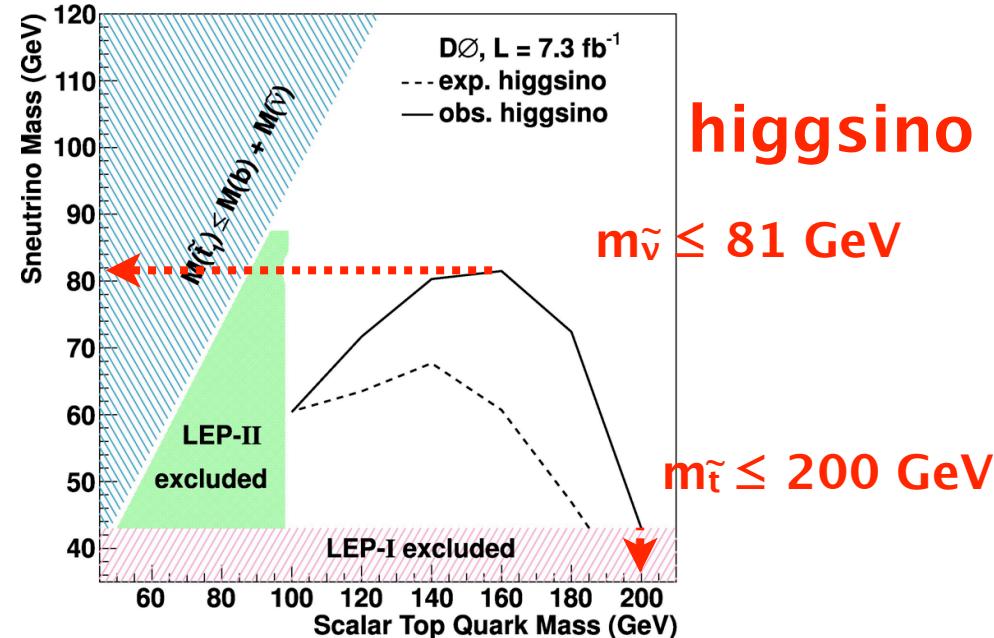
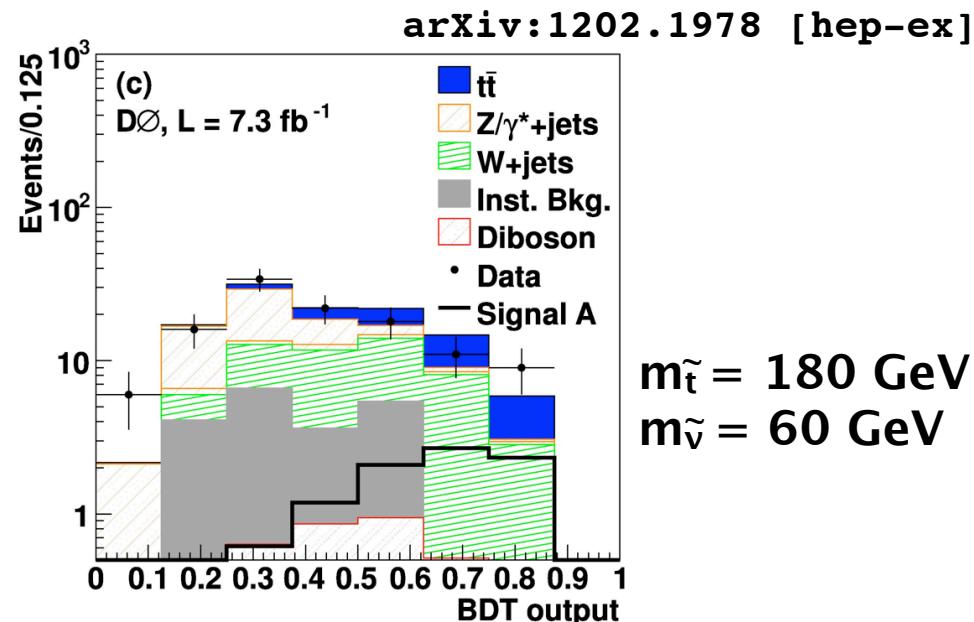
Search for Stop Pair Production



$\tilde{t}_1\tilde{t}_1 \rightarrow b\bar{b}\mu\tau E_T$

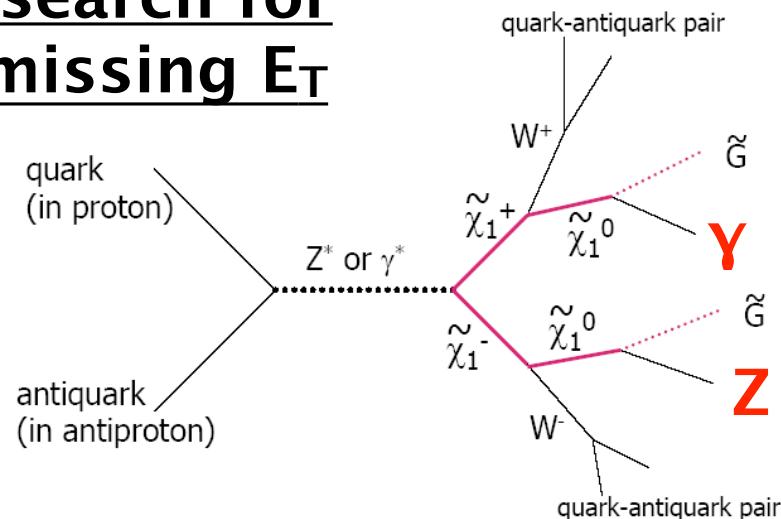


first Tevatron limits

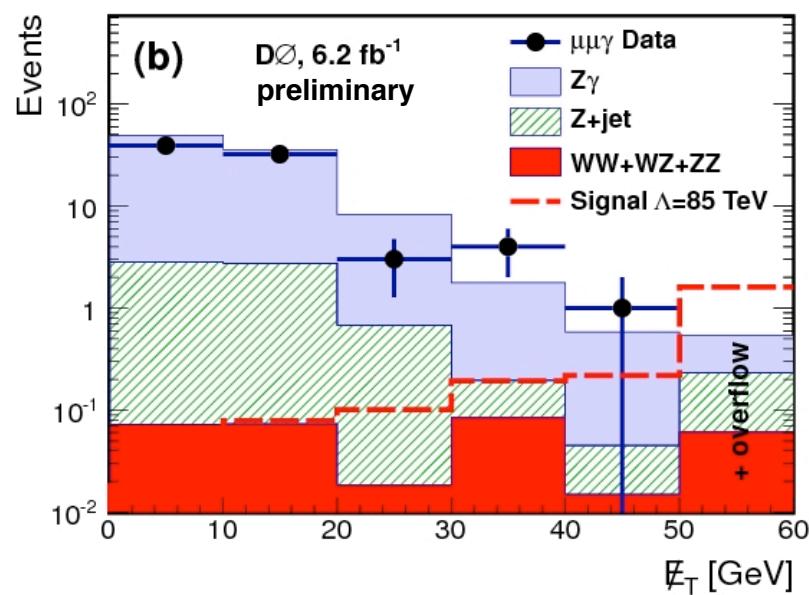
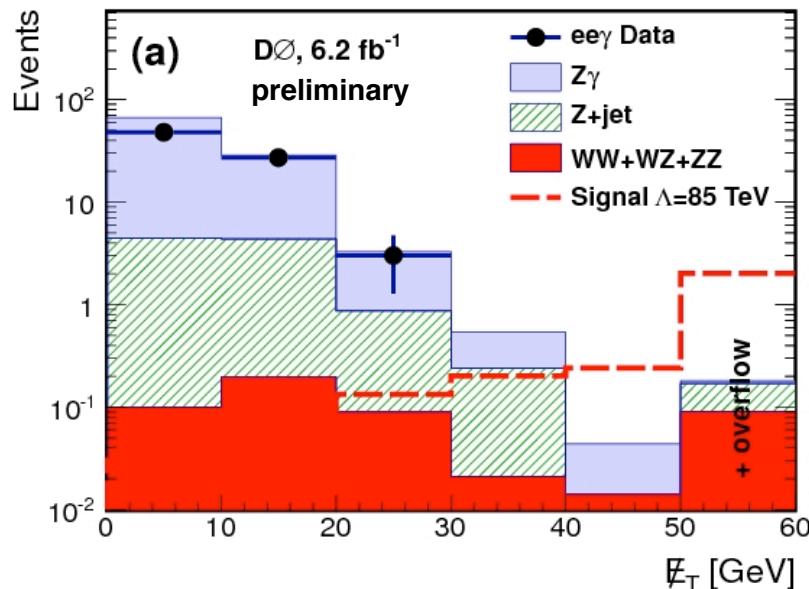


Search for Gravitinos (GMSB SUSY)

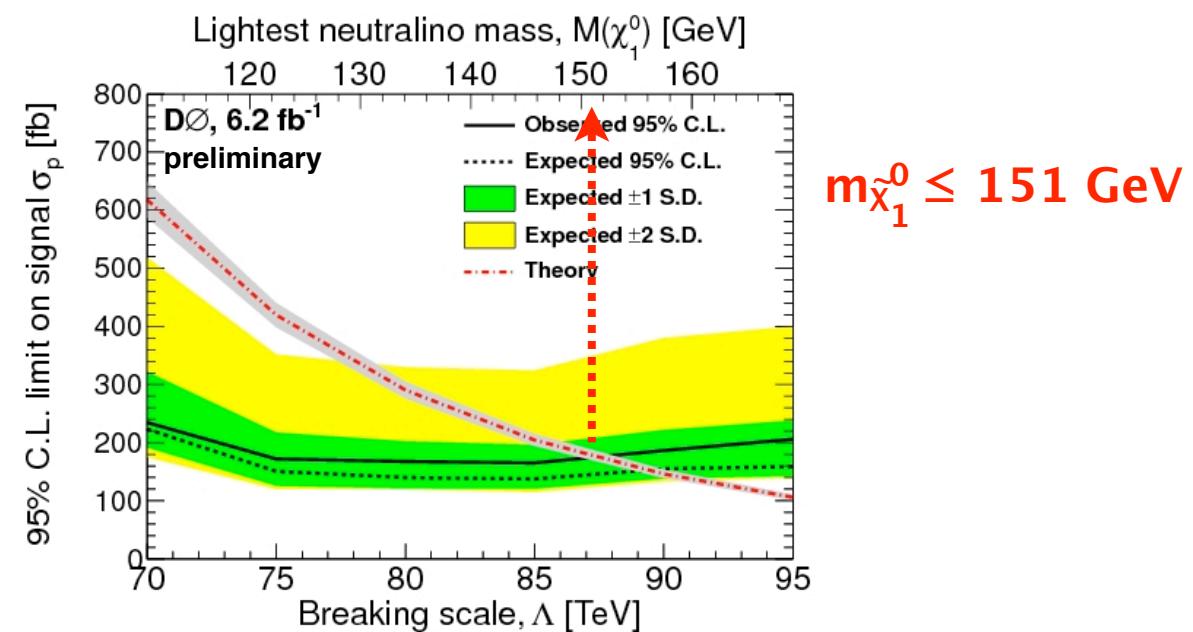
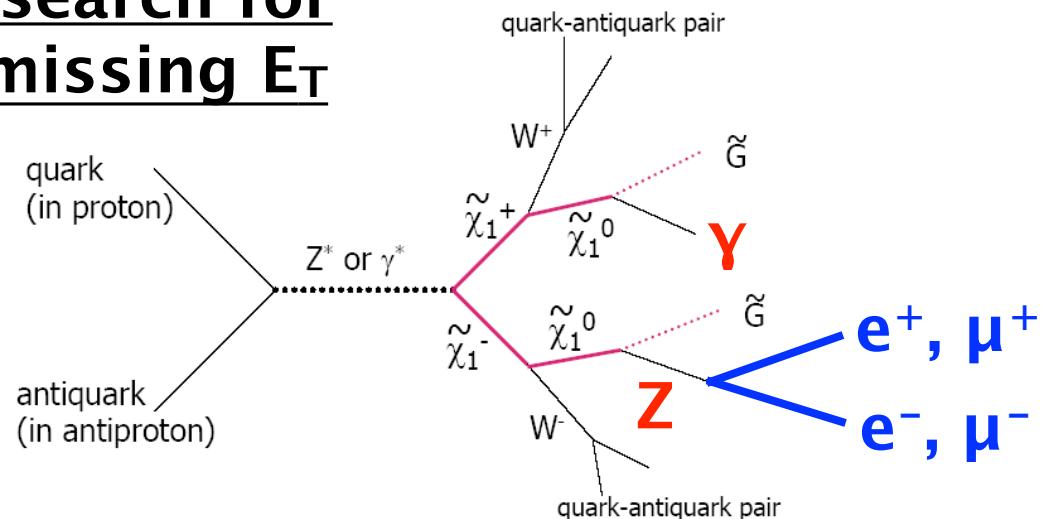
first search for $Z\gamma + \text{missing } E_T$



Search for Gravitinos (GMSB SUSY)

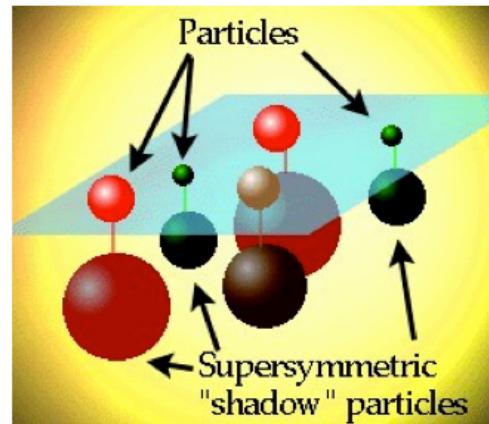


first search for $Z\gamma + \text{missing } E_T$



Beyond the Standard Model

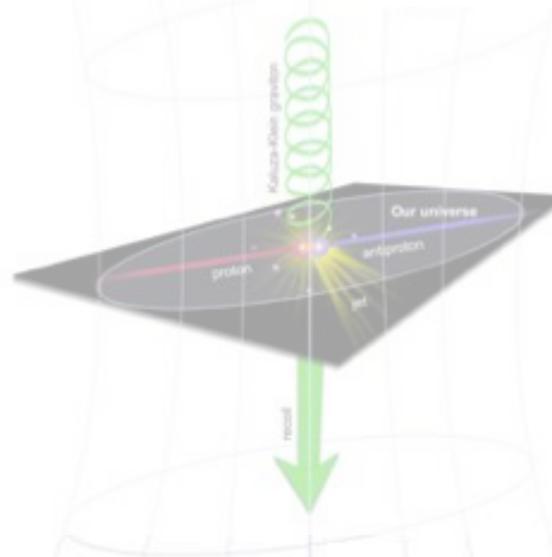
Supersymmetry



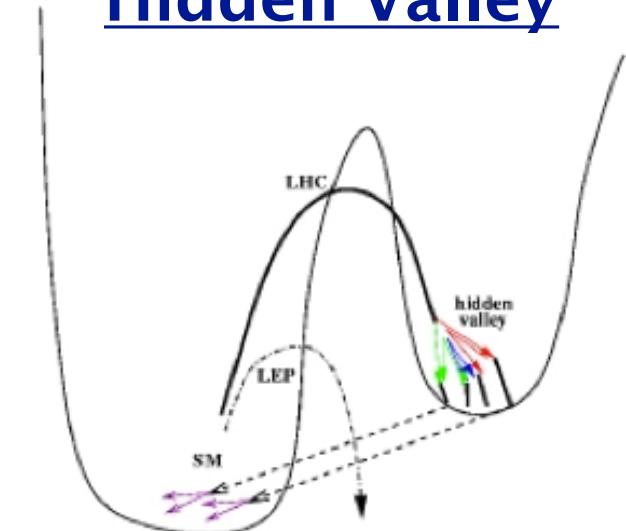
Name	Spin	Superpartner	Spin
Electron	1/2	Selectron	0
Muon	1/2	Smuon	0
Tau	1/2	Stau	0
Neutrino	1/2	Sneutrino	0
Quark	1/2	Squark	0

Name	Spin	Superpartner	Spin
Graviton	2	Gravitino	3/2
Photon	1	Photino	1/2
Gluon	1	Gluino	1/2
$W^{+,-}$	1	Wino $^{+,-}$	1/2
Z^0	1	Zino	1/2
Higgs	0	Higgsino	1/2

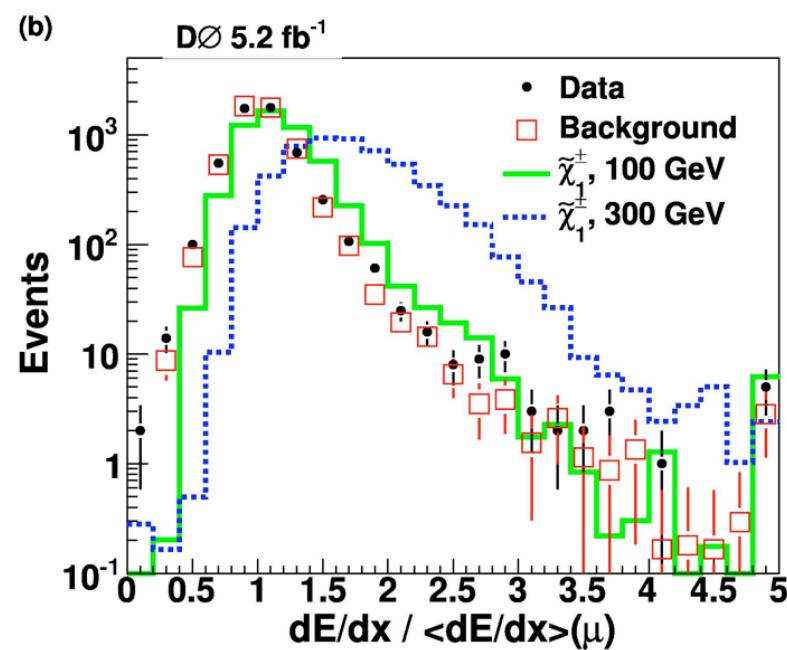
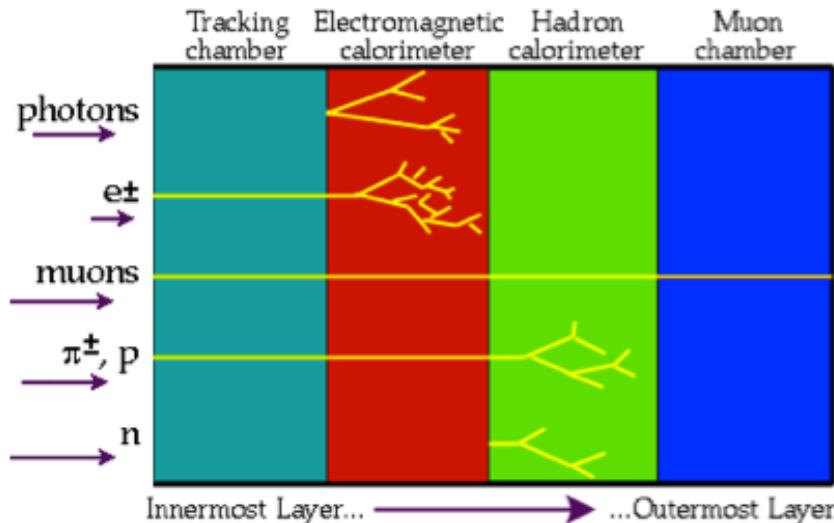
Extra dimensions



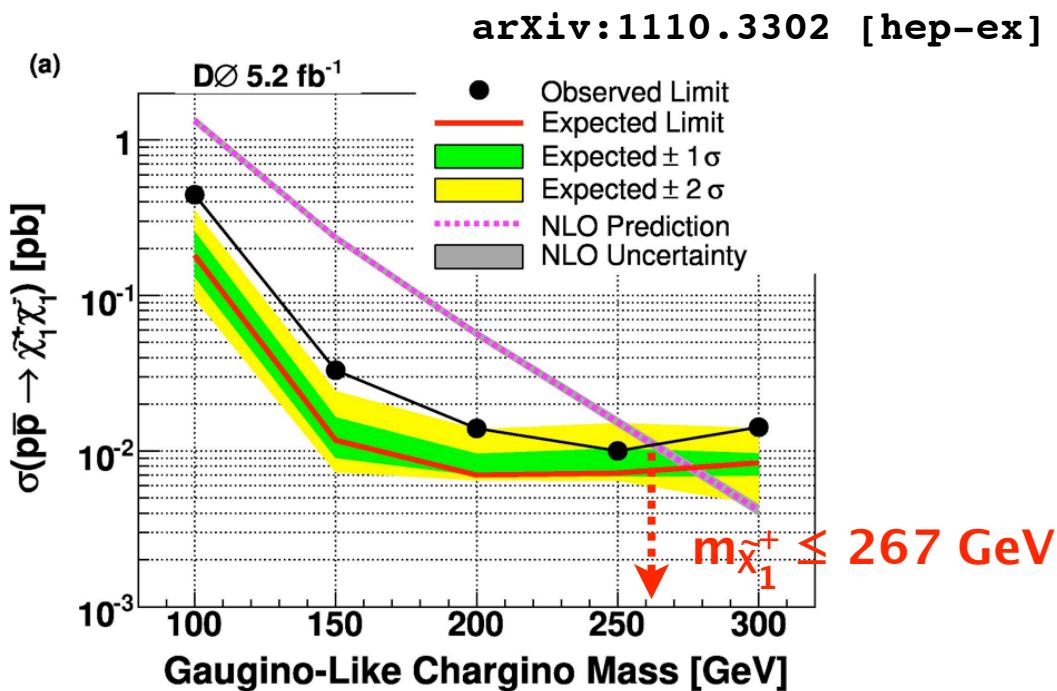
Hidden Valley



Charged Massive Long-Lived Particles

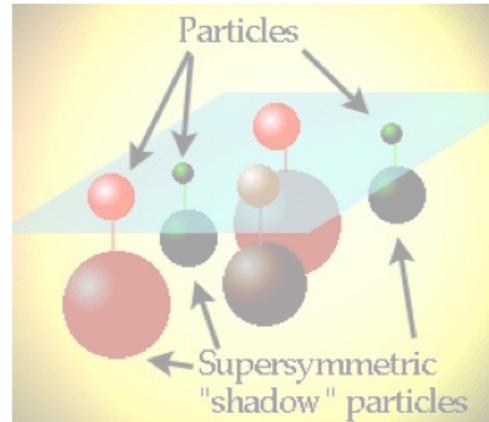


- could resolve problems in cosmology (observed lithium production which is difficult to explain in the standard model of big bang nucleosynthesis)
- in SUSY models with AMSB, the NLSP can be a CMLLP, e.g. chargino
- look like slow, massive long-lived muons: measure speed and ionisation energy loss



Beyond the Standard Model

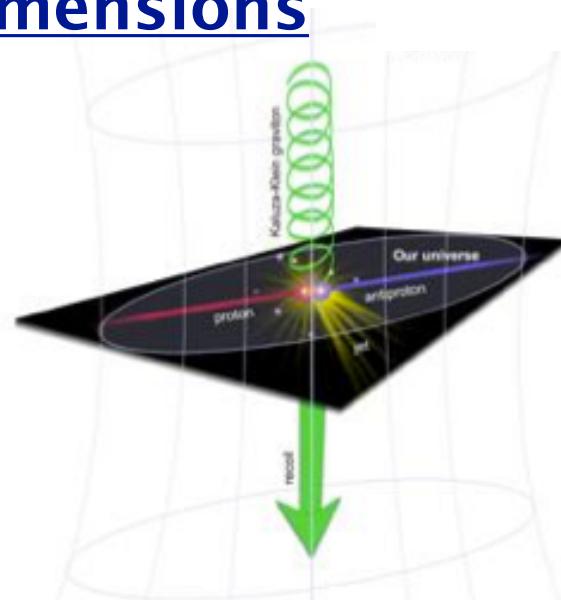
Supersymmetry



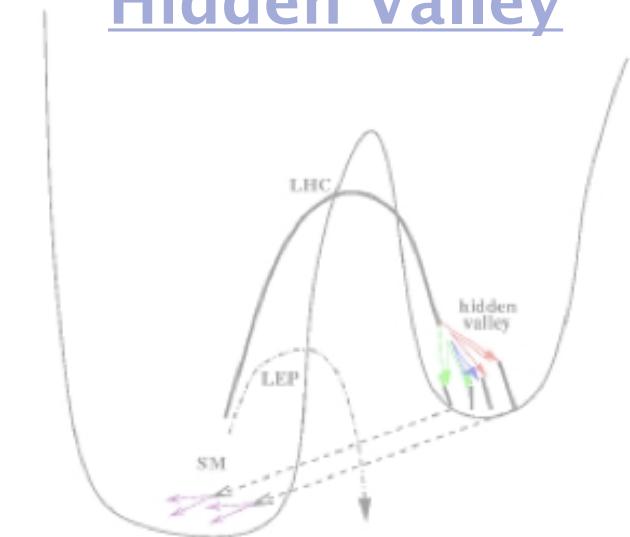
Name	Spin	Superpartner	Spin
Electron	1/2	Selectron	0
Muon	1/2	Smuon	0
Tau	1/2	Stau	0
Neutrino	1/2	Sneutrino	0
Quark	1/2	Squark	0

Name	Spin	Superpartner	Spin
Graviton	2	Gravitino	3/2
Photon	1	Photino	1/2
Gluon	1	Gluino	1/2
$W^{+,-}$	1	Wino $^{+,-}$	1/2
Z^0	1	Zino	1/2
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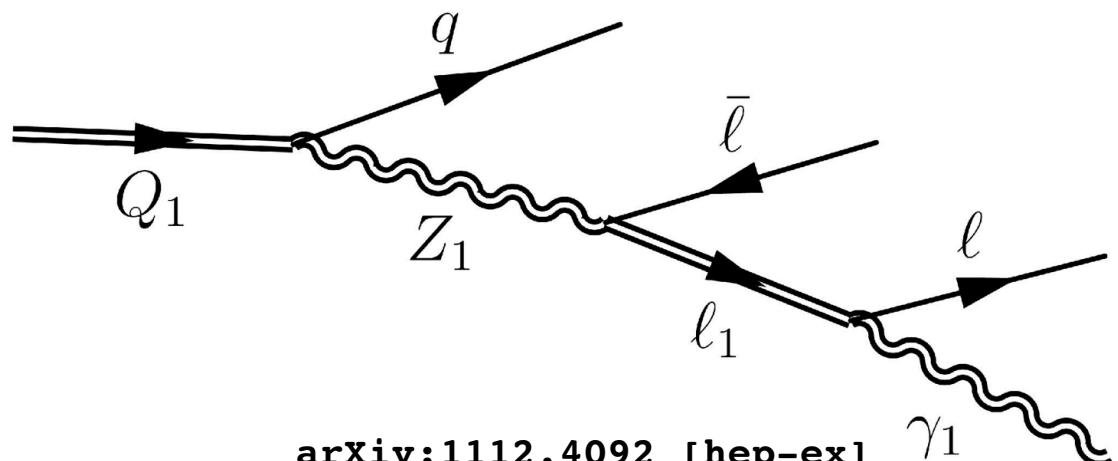
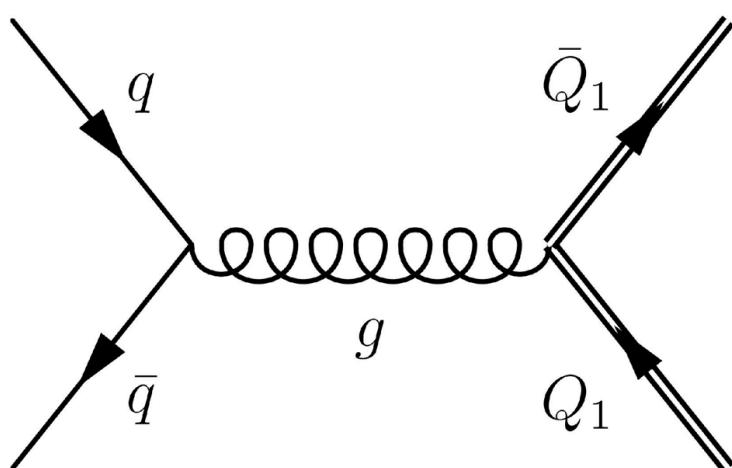
Extra dimensions



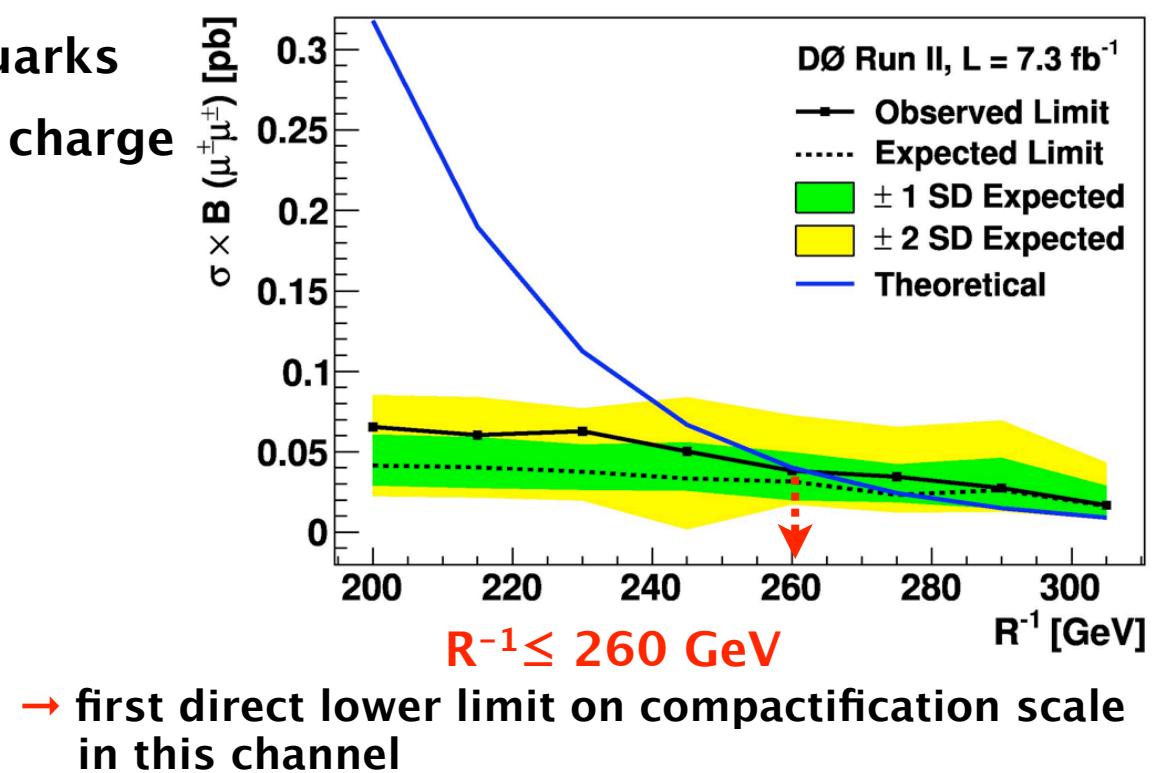
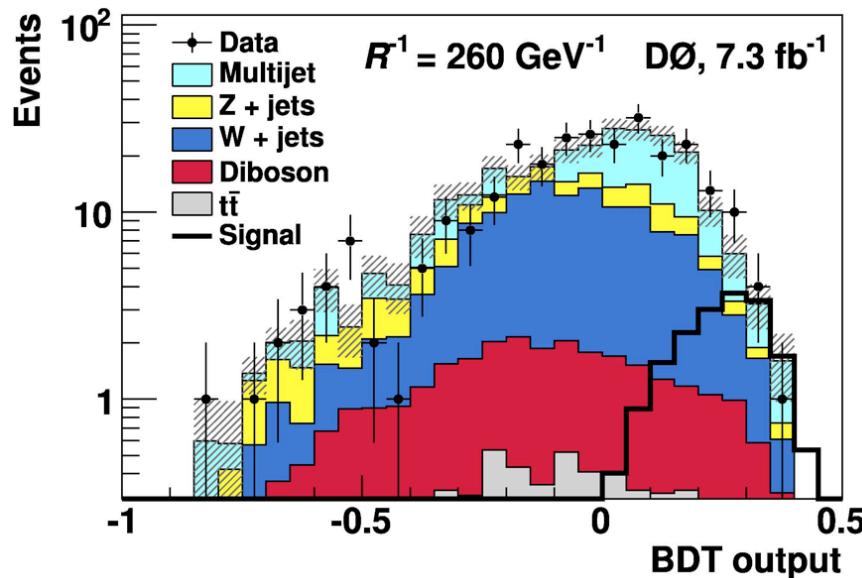
Hidden Valley



Minimal Universal Extra Dimensions

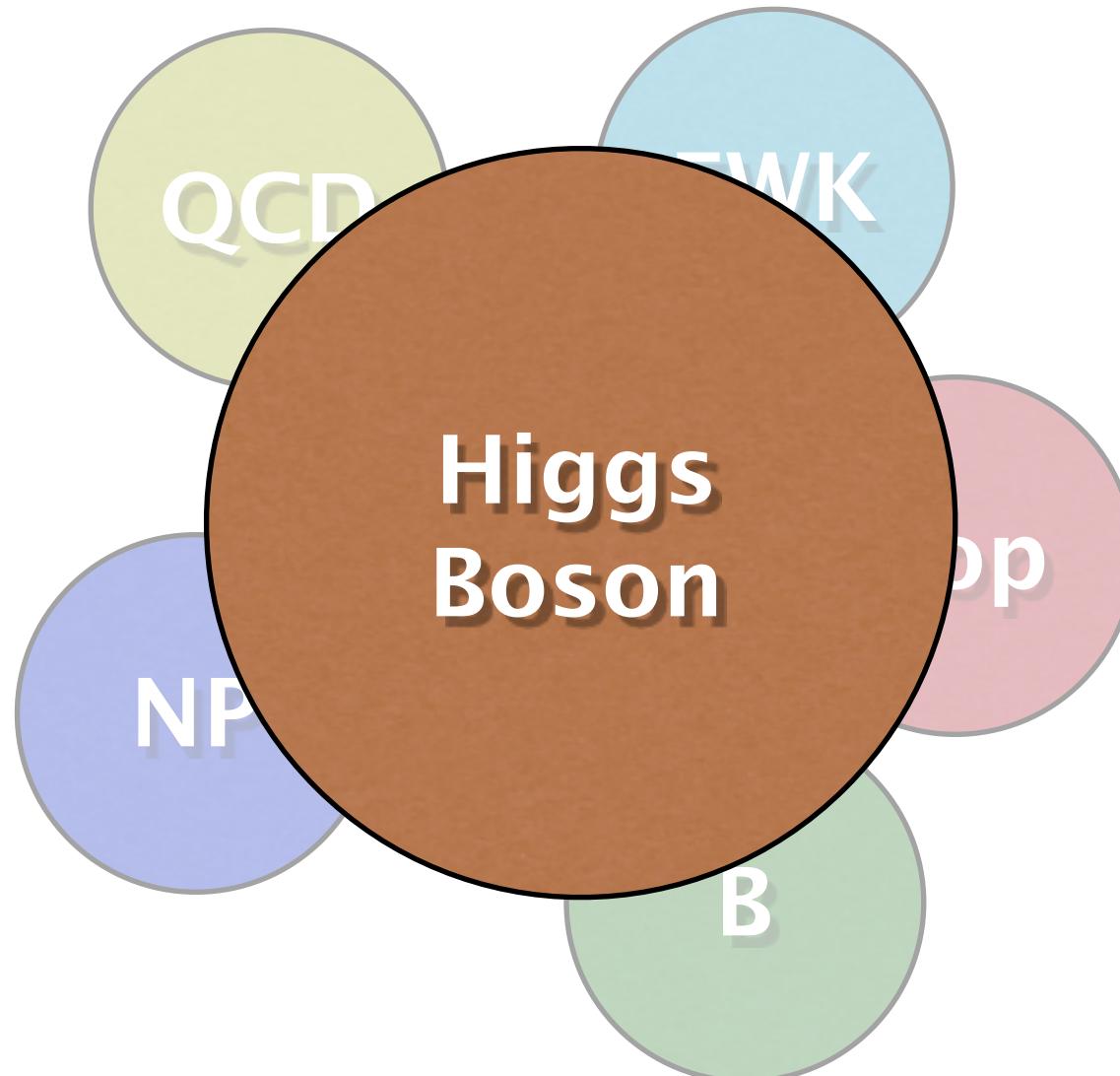


- pair production of Kaluza-Klein quarks
- search for 2 muons with the same charge



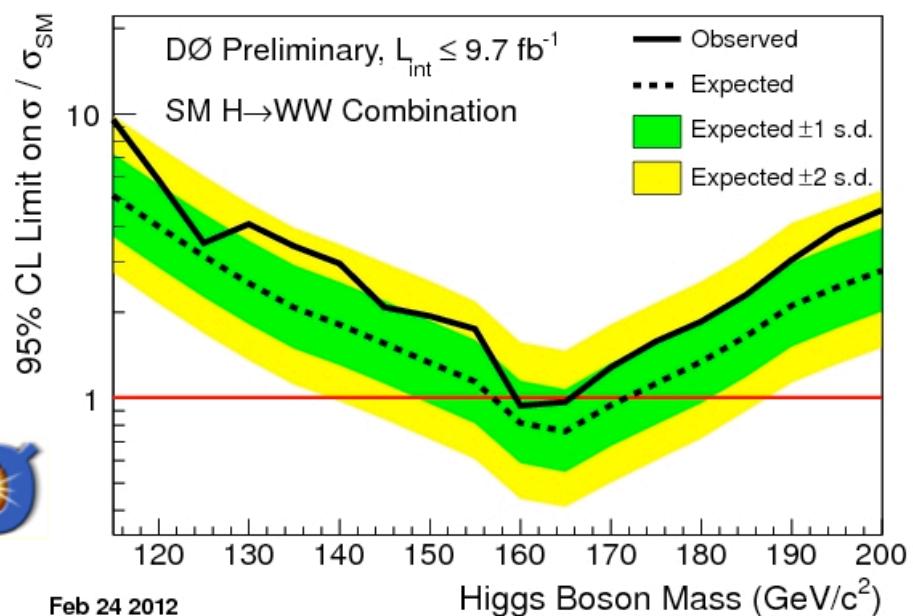
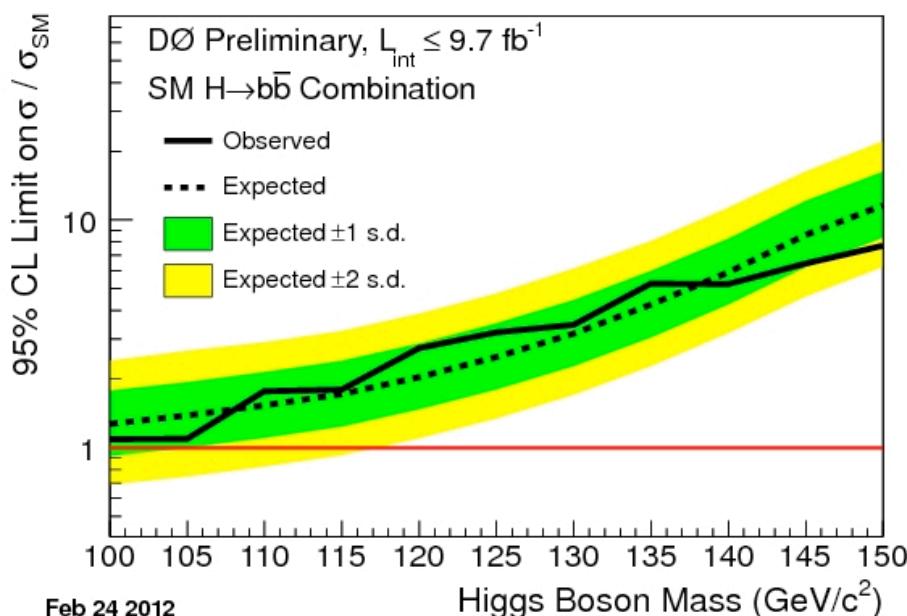
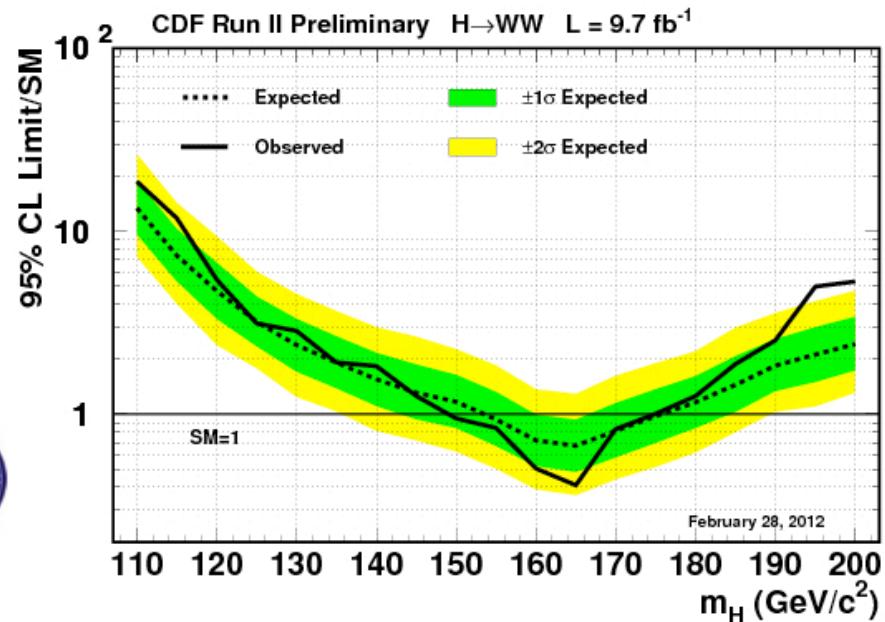
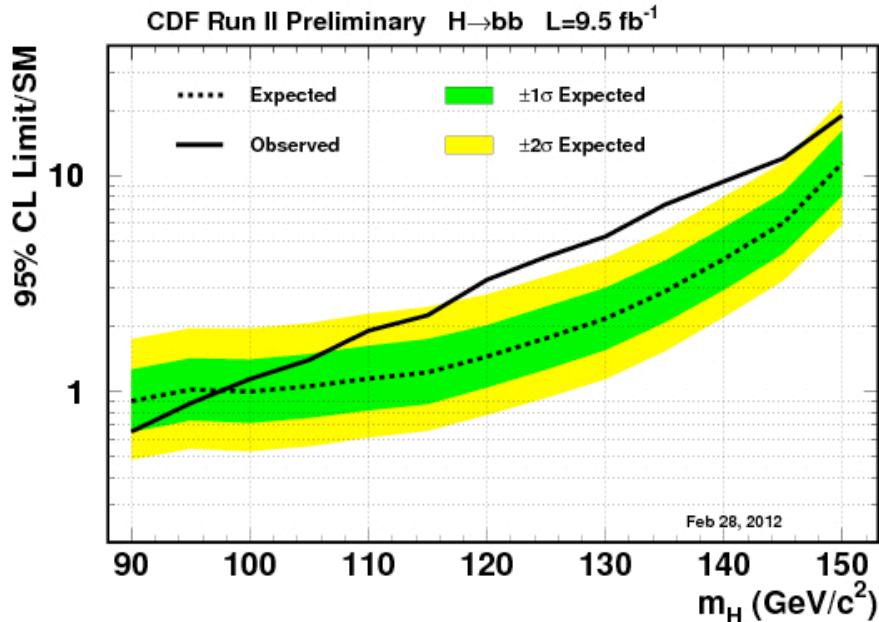
→ first direct lower limit on compactification scale in this channel

DØ Physics Results for Winter 2012

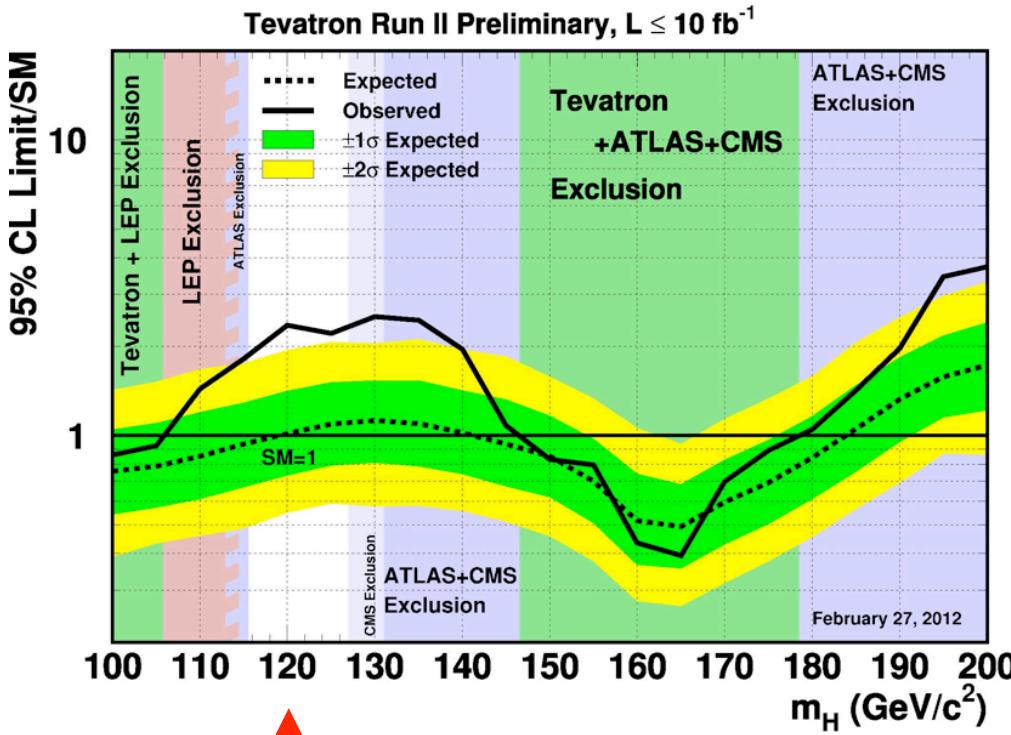


SM Higgs Search

10 fb^{-1}



SM Higgs Search

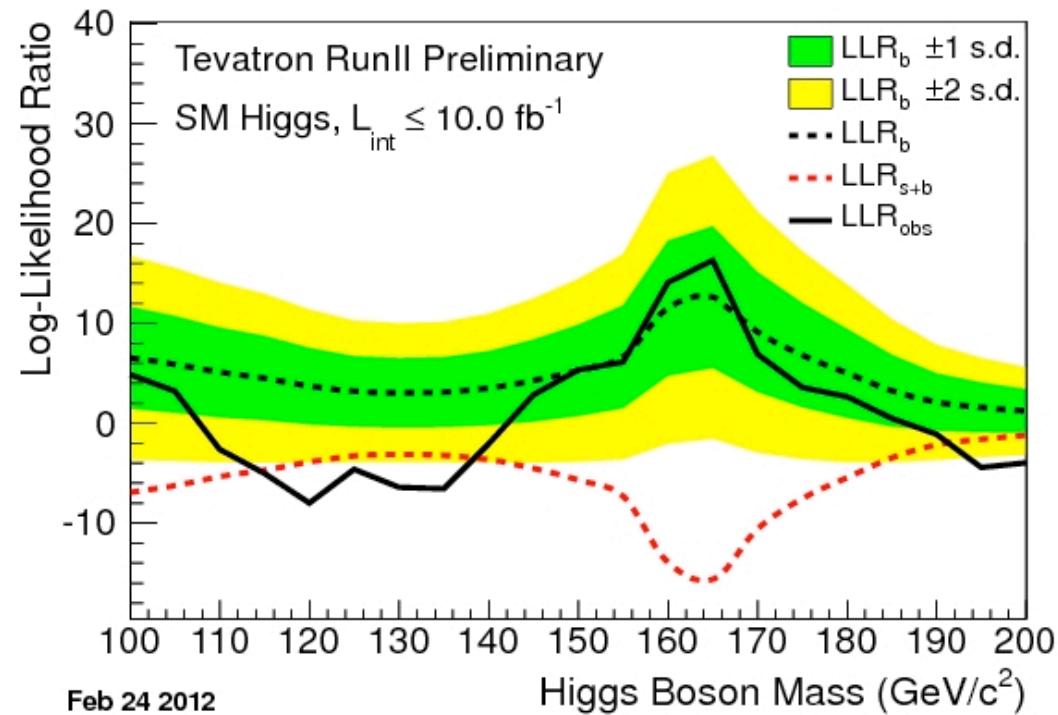


2.7 σ (local)
2.2 σ (global)



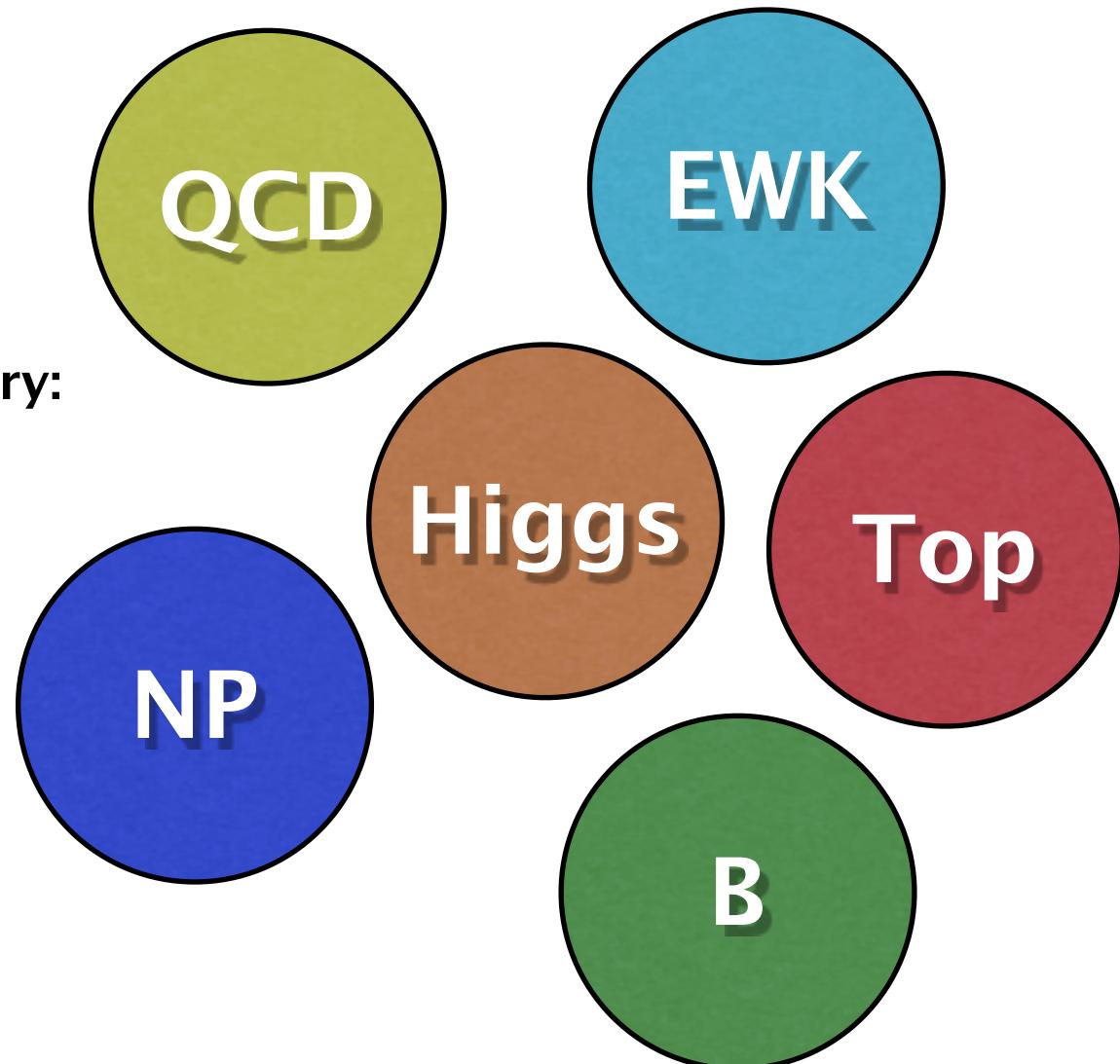
10 fb^{-1}

Satish Desai,
Michelle Stancari,
March 7



Summary

- many exciting new results for the winter conferences!
- many analyses are competitive with the LHC
- some analyses are complementary:
evidence for $t\bar{t}$ spin correlation
- W mass uncertainty: 0.019%
we can double the dataset
⇒ SM is self-consistent
- Tevatron is unique due to sensitivity to $H \rightarrow b\bar{b}$ decay
increase sensitivity further
⇒ excess in the range
 $115 < m_H < 135$ GeV

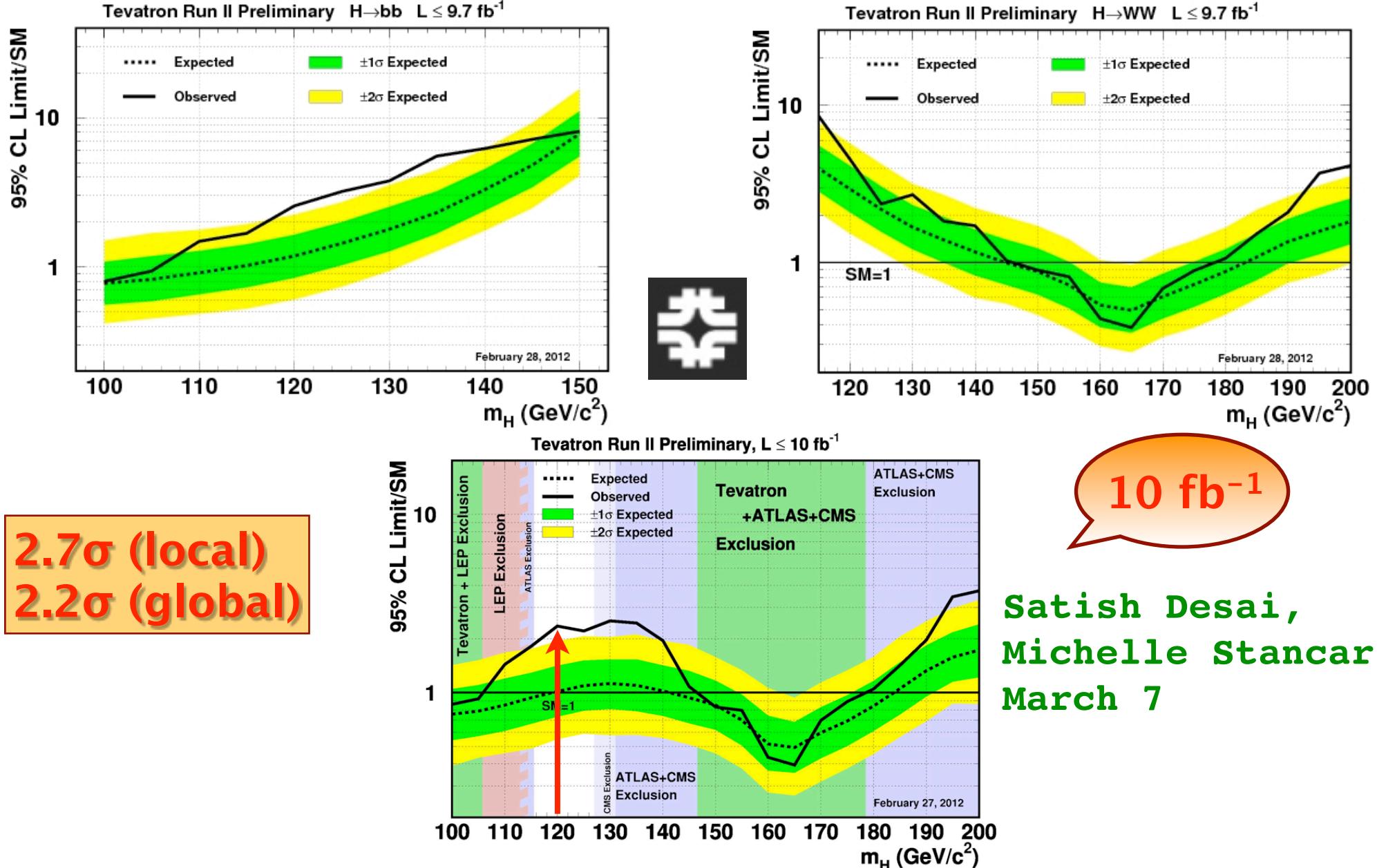


Thanks to all DØ colleagues who have contributed!

Backup



SM Higgs Search



Matrix Element Method: spin correlation

H=uncorrelated

G. Mahlon and S. J. Parke,
Phys. Rev. D 53, 4886 (1995)
Phys. Lett. B 411, 173(1997)

$$\sum |\mathcal{M}|^2 = \frac{g_s^4}{9} F\bar{F} (2 - \beta^2 s_{qt}^2) / 2$$

kinematics of top
and anti-top decay

β : velocity of top in $t\bar{t}$ rest frame
 s_{qt} : sine between initial quark and top



Matrix Element Method: spin correlation

β : velocity of top in $t\bar{t}$ rest frame

s_{qt} : sine between initial quark and top

c_{qt} : cosine between initial quark and top

G. Mahlon and S. J. Parke,
Phys. Rev. D 53, 4886 (1995)
Phys. Lett. B 411, 173 (1997)

$$\sum |\mathcal{M}|^2 = \frac{g_s^4}{9} F\bar{F} [(2 - \beta^2 s_{qt}^2) - \Delta]$$

kinematics of top
and anti-top decay

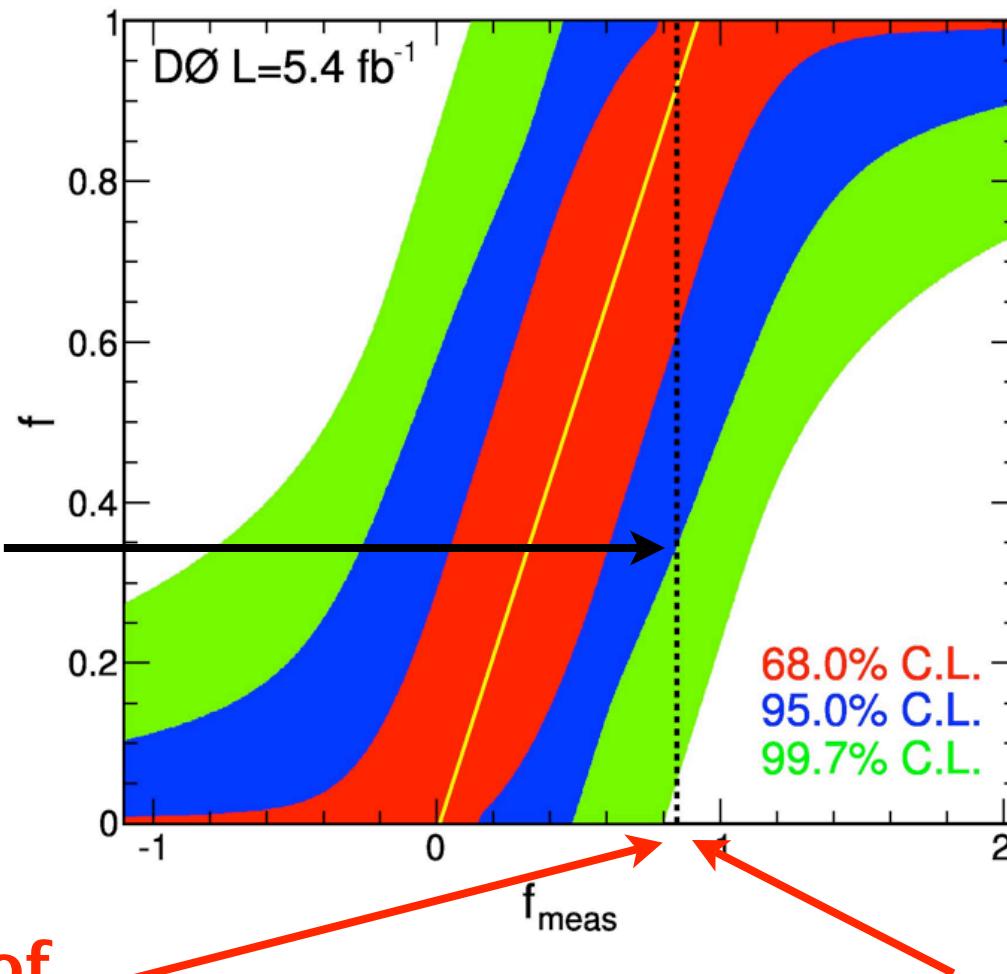
H=correlated

$$\Delta = \frac{(1 - c_{\ell q} c_{\ell \bar{q}}) - \beta(c_{\ell \bar{t}} + c_{\bar{\ell} t}) + \beta c_{qt}(c_{\ell q} + c_{\ell \bar{q}}) + \frac{1}{2}\beta^2 s_{qt}^2(1 - c_{\ell \ell})}{\gamma^2(1 - \beta c_{\bar{\ell} t})(1 - \beta c_{\ell \bar{t}})}$$



Exclusion Limits

$$C = 0.66 \pm 0.23 (\text{stat+syst})$$



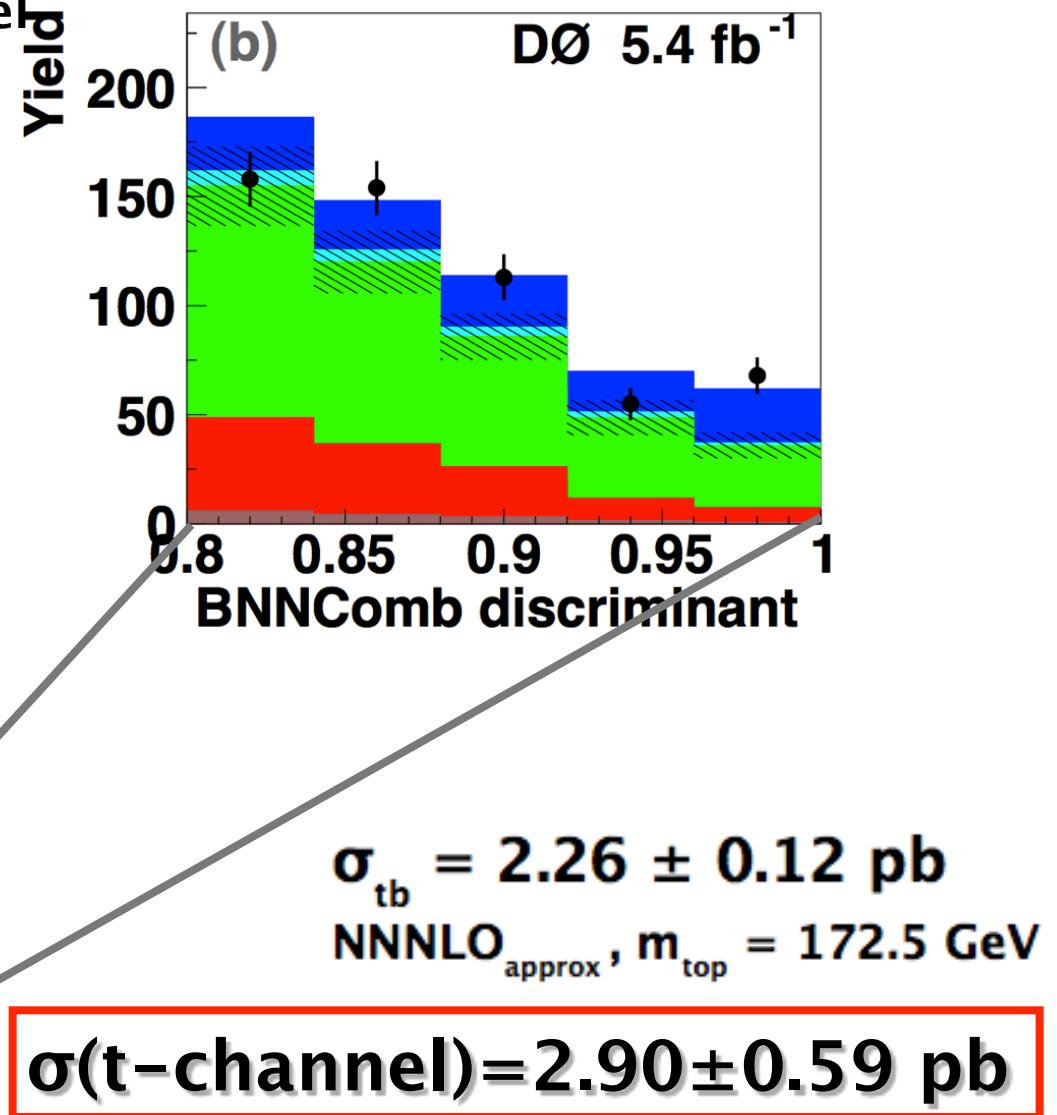
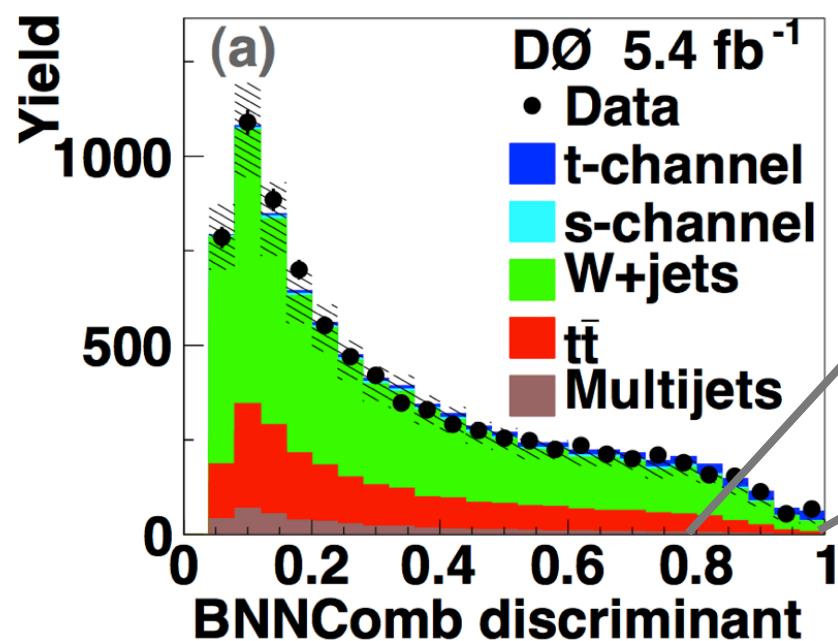
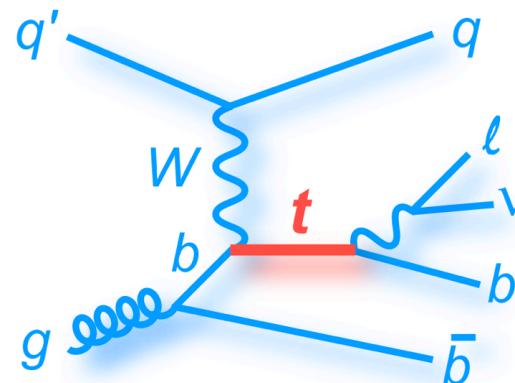
$f > 0.344$
at 95% CL

first exclusion of
hypothesis $H=\text{uncorrelated}$
($f=0$) with more than 3σ

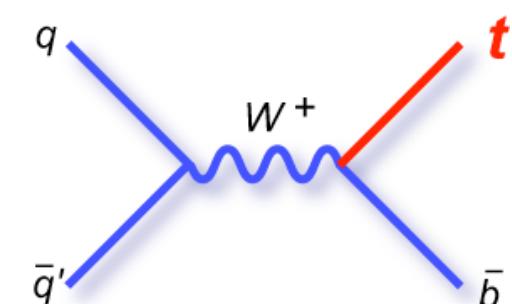
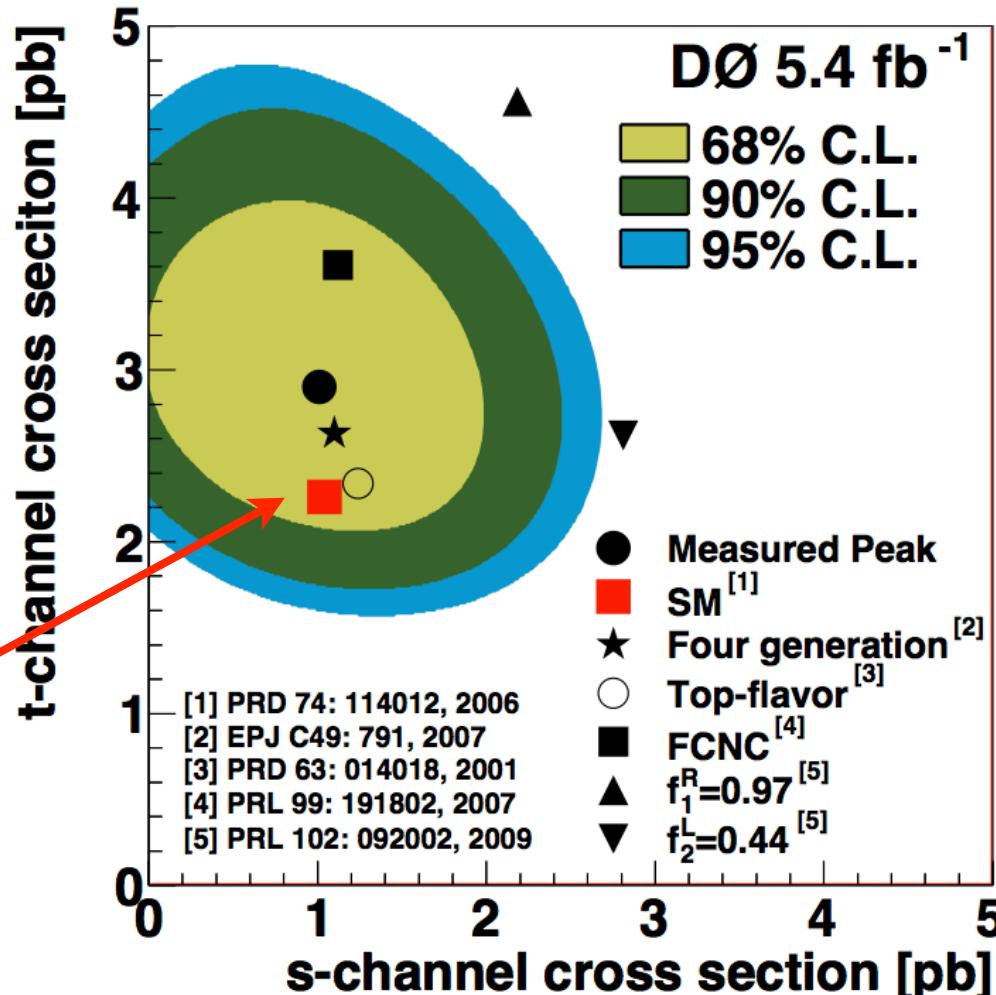
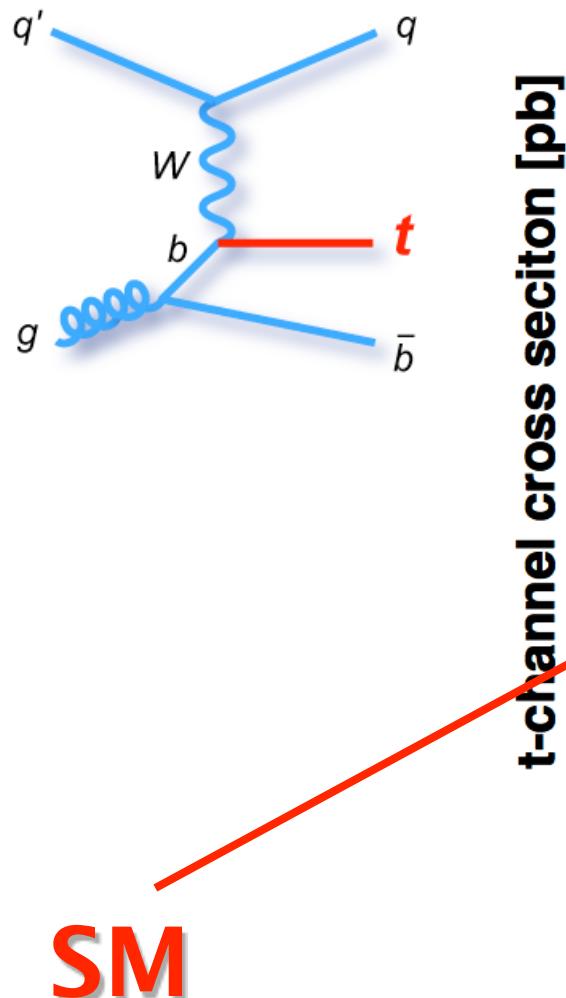
$$f_{\text{meas}} = 0.85 \pm 0.29 (\text{stat + syst})$$

Single Top t-channel

- 2, 3, 4 jets with 1, 2 b tags
- train multivariate analysis for t-channel
- double data set

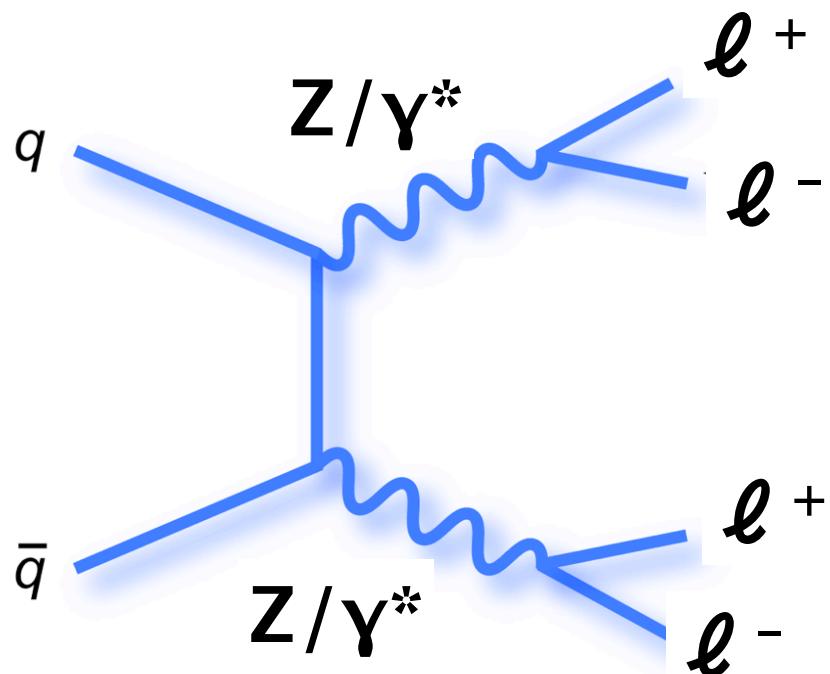


Single Top s- vs. t-channel



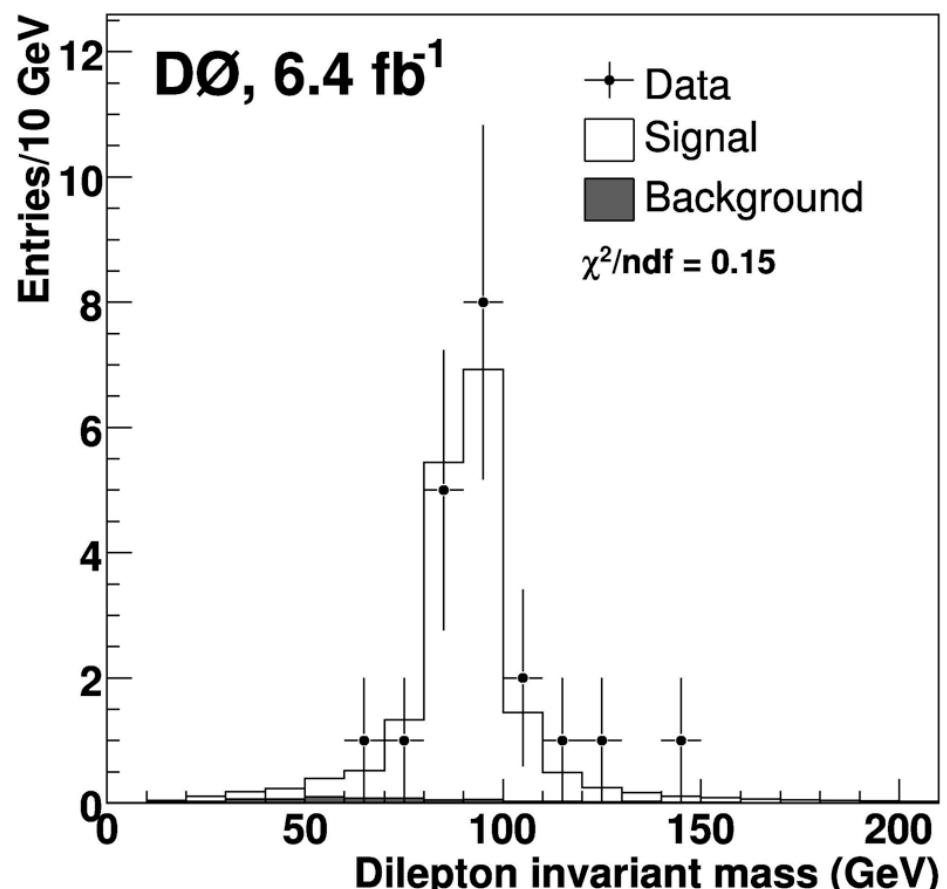
good agreement with Standard Model

$ZZ \rightarrow \ell^+ \ell^- \ell^+ \ell^-$ Production

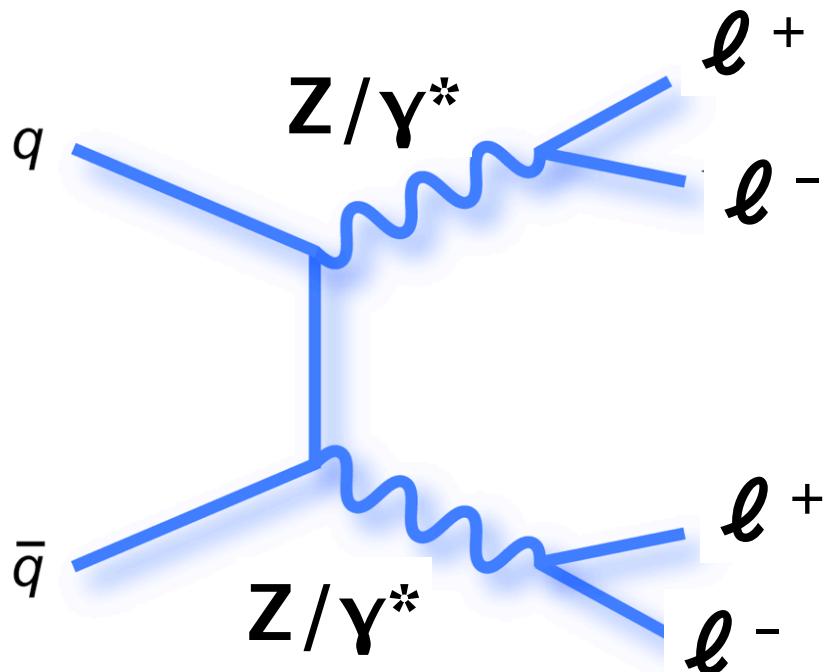


important background
to $H \rightarrow ZZ$ searches

$eeee, ee\mu\mu, \mu\mu\mu\mu$

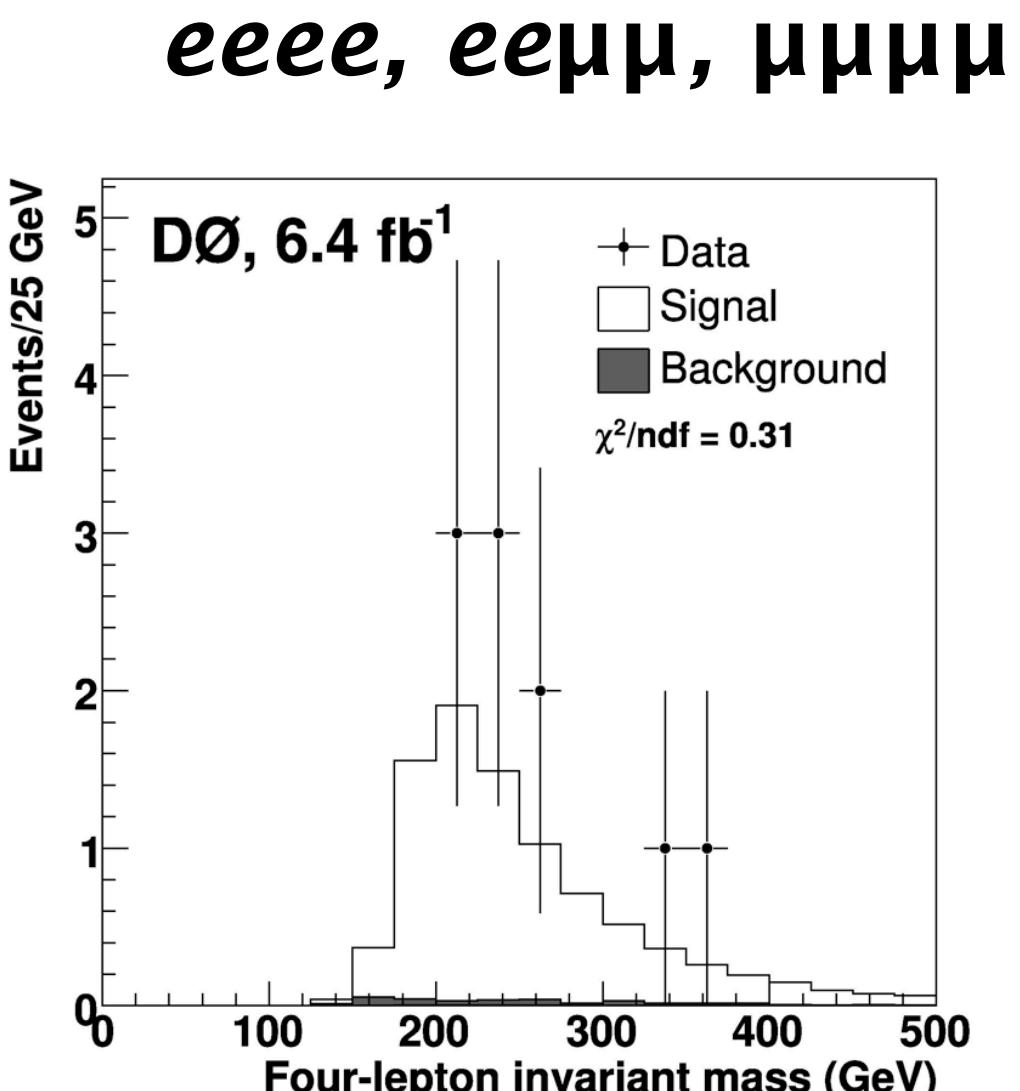


$ZZ \rightarrow \ell^+ \ell^- \ell^+ \ell^-$ Production

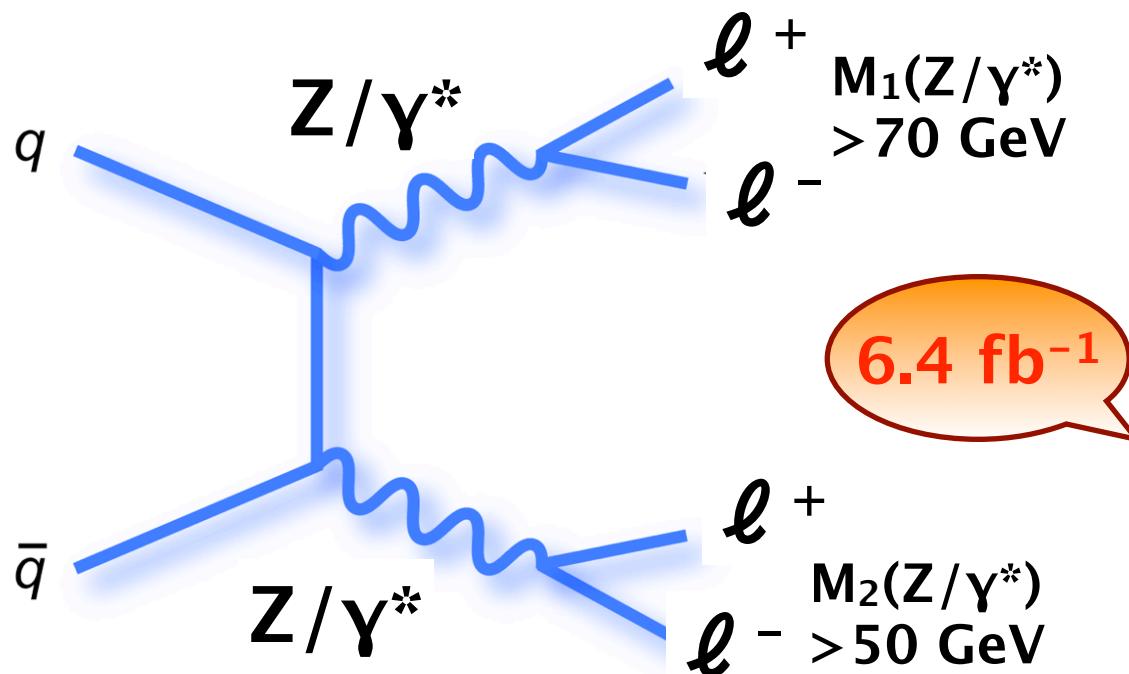


important background
to $H \rightarrow ZZ$ searches...

- data: 10 events
- signal: 8.73 ± 0.45
- background: 0.35 ± 0.04
(jets faking electrons,
muons in jets, top pair
production)



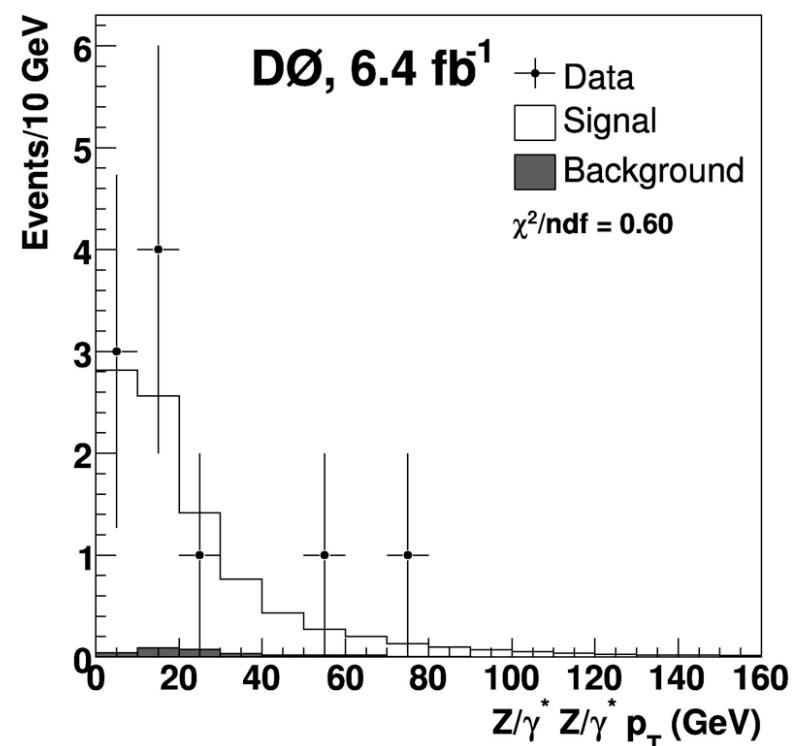
$ZZ \rightarrow \ell^+ \ell^- \ell^+ \ell^-$ Production



SM: $\sigma(Z/\gamma^*Z/\gamma^*) = 1.4 \pm 0.1 \text{ pb}$

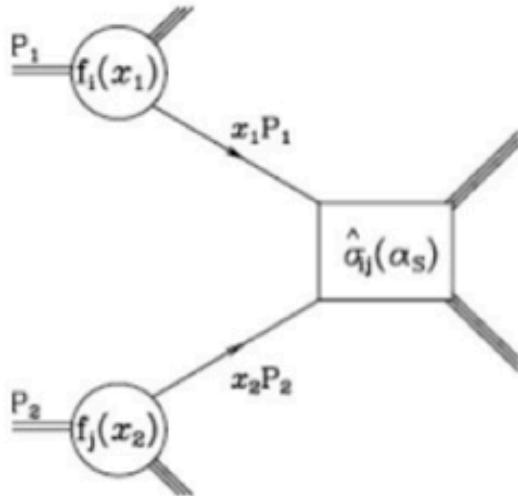
$$\sigma(p\bar{p} \rightarrow Z/\gamma^*Z/\gamma^*) = 1.35^{+0.50}_{-0.40} (\text{stat}) \pm 0.15 (\text{syst}) \text{ pb}$$

$eeee, ee\mu\mu, \mu\mu\mu\mu$

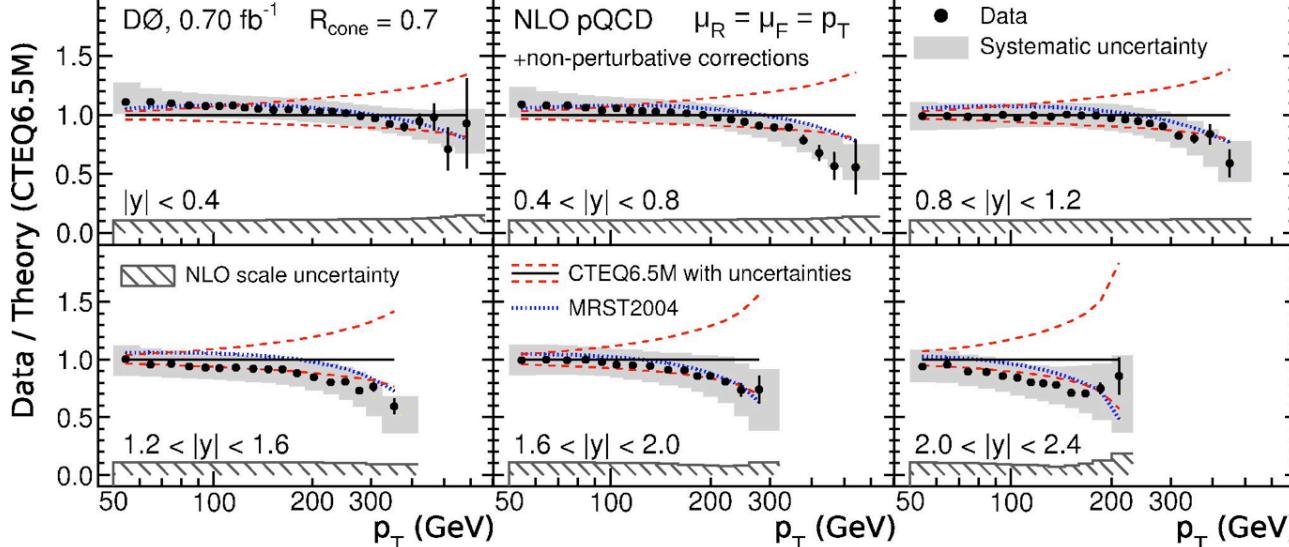
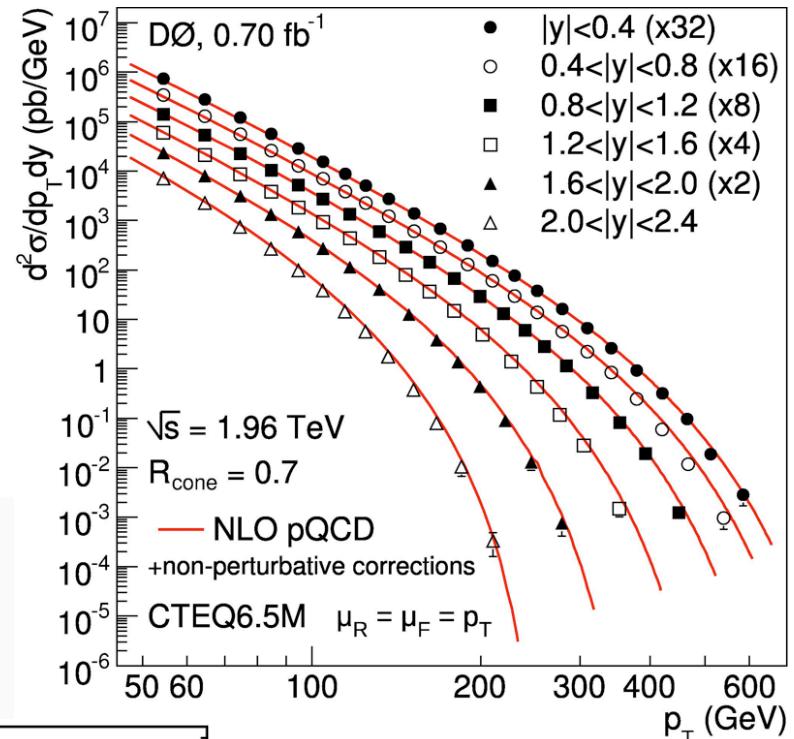


- smallest cross section measured at hadron collider
- most precise measurement
- examine kinematic distributions

Inclusive Jet Cross Section



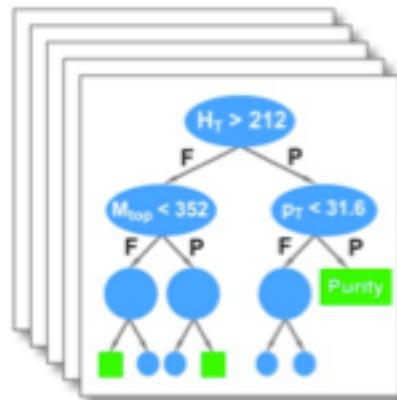
- constrain pdfs (here: CTEQ6.5M)



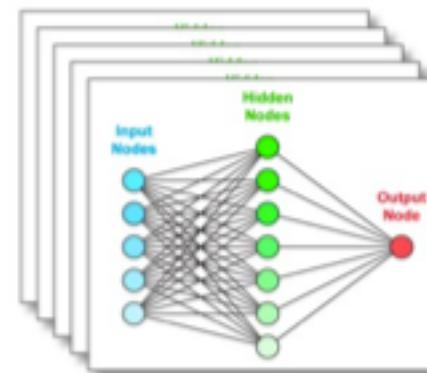
- excellent agreement with QCD prediction over 9 orders of magnitude
- no excess at high E_T :
→ no hint for quark substructure

Multivariate Analyses

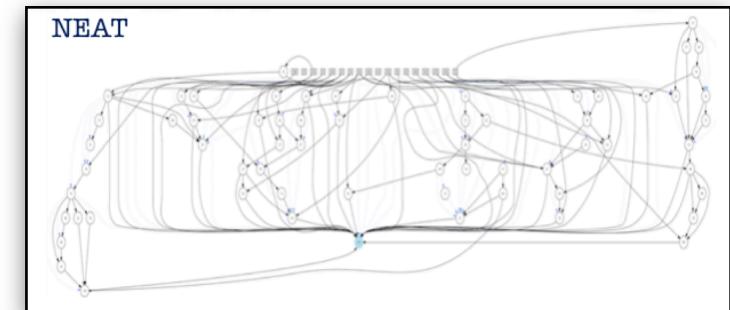
Boosted Decision Trees



Boosted Neural Networks



Neuroevolution of Augmenting Topologies



background **signal**

